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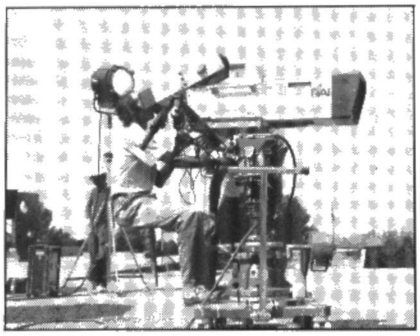

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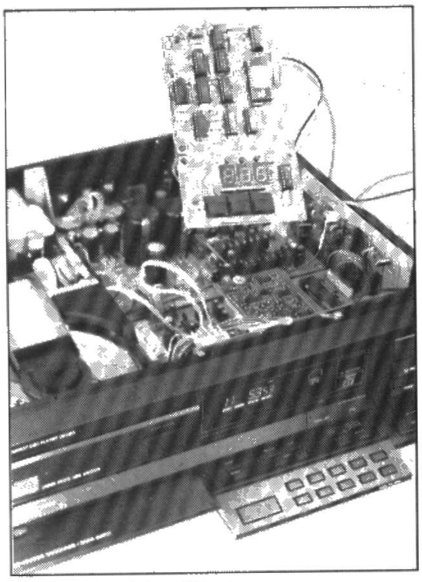

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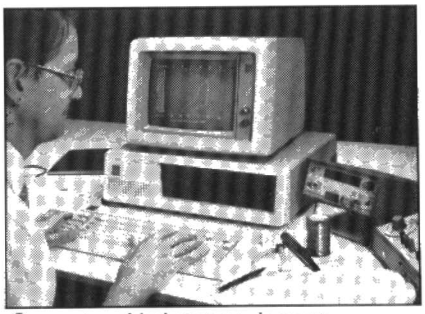

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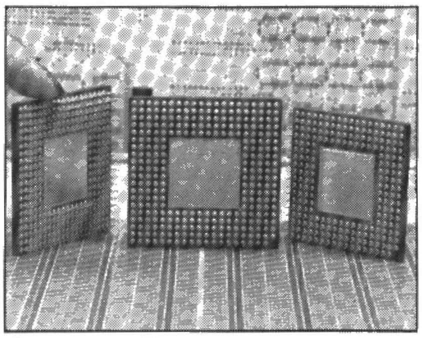

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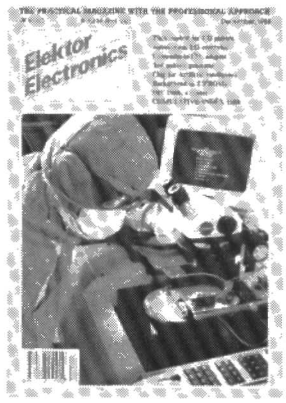

Front cover

The design of microcircuits is becoming more challenging every year. Plessey's Roborough silicon wafer fabrication plant in Plymouth produces CMOS chips that require much less power than other types and are particularly suited to telecommunications, computers, traffic controls and robots. Completed wafers are subjected to comprehensive testing to guarantee performance and to provide data for process control.

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TOWARDS THE INTELLIGENT HOUSE

Nearing the end of the year, it is, perhaps, instructive (and fun) to take the recent remarks by British Telecom's chief executive and chairman, Mr Iain Vallance, a little further and take an inspired look at what changes we are likely to see in our domestic environment of the future.

Homes will be equipped increasingly with a domestic computer terminal (put in by the builders like a sink unit). This will control the central heating, hot water supply, cooker, video, lighting, and so on. Eventually, there will be a fully automated kitchen that will carry out most of the irksome tasks like ironing and washing up.

This domestic computer will be controlled via the public telephone network. The conventional telephone will be replaced by a wristwatch type, so that the home can be controlled from wherever you are.

The conventional door lock will disappear and be replaced by tone-detecting electronic locks that respond to the householders' voices.

Although the combustion-engine-driven car will not disappear for a long time to come, there will be an increasing number of electric cars. New, small, large-capacity batteries will make these a commercially viable proposition. All cars will be fitted with a large number of electronic gadgets to take the tediousness out of driving. They will have microprocessors that control fuel injection, gear changing, spring rate, vehicle height, shock absorber damping, and others. All cars will be equipped with anti-brake-lock systems and sensors that actuate the braking-system when you get too close to the car in front.

Increasingly, shopping will be done from home with the aid of video-telephones and electronic fund transfer.

Home entertainment will be based on digital equipment, and probably be interactive, allowing subscriber selection of high-definition, 3D, large-screen, video, television, and music via common networks.

Television and video communications will dominate the home even more than they do now. With more and more satellites hovering above the equator, signals from them will be received via dishes not much larger than a dinner plate. The screens will be linked in with the telephone network so that all communications will be face-to-face.

Cellular radio systems, linked world-wide by satellite systems will be commonplace so that anyone can communicate with anybody else wherever they may be.

Paraplegics may be able to walk again with the aid of electrical stimulation of their muscles. These stimuli will come from pressure, angular, and acceleration sensors on their limbs.

The deaf will have portable videophones in which a microprocessor displays the incoming telephone speech on to a screen.

Electronic devices will continue to get smaller and faster, although the size of finished products will, of course, still be dictated by the needs of the user. Slowly but surely, silicon ICs will be replaced by gallium-arsenide chips, and these, in turn, will be superseded by neural or optical devices. The density of these devices will be staggering by current standards.

The future certainly looks exciting, the more so for those of us who play an active part in the wonderful world of electronics!

BUS INTERFACE FOR HIGH-RESOLUTION LIQUID CRYSTAL SCREENS

Part 2

Construction

The LC screen interface is constructed on a double-sided, through-plated printed circuit board (see Fig. 4). The track layout is not given here because this PCB is virtually impossible to make other than from films, while through-plating equipment is usually only available in a professional workshop.

The size of the ready-made PCB is such that it can be attached to the controller board of the LM40001 unit with the aid of 4 spacers. The connection between the interface board and the existing controller board is conveniently made in a short length of 10-way flat ribbon cable. The mounting of the standard-sized components on the board should not present difficulties. Only the controller, IC_8, deserves special attention. This IC is housed in a 64-pin flatpack enclosure for surface mounting, with pins in a 1 mm, rather than a 0.1 in., raster. Use a low-power soldering iron with a small tip to solder the terminal pins of the controller direct on to the relevant copper tracks. Work very carefully, and use desoldering braid to remove solder when a short-circuit is made between adjacent pins. As to orientation of the controller chip on the board, stick to the component overlay, because pin 1 is not located immediately next to the bevelled edge of the enclosure!

Connector K_1, a 40-way PCB header with eject handles, is secured on to the PCB by means of two small bolts and nuts. The pinning of K_1 makes it possible to use a direct, pin-to-pin, connection, in flatcable, to the expansion connector on the BASIC computer [1]. For other computer systems, it is necessary to provide a do-it-yourself connection between K_1 and the bus (see Tables 3a and 3b). Whatever connection is used, the total length of the cable between the computer bus and K_1 should not exceed 30 cm or so.

Programming the LC screen interface

Software for producing ASCII characters on the LC screen is relatively simple to produce thanks to the con-

Table 2 Interface configuration data

Processor		Z80* (MSX)		6502		IBM-PC*		ELEKTOR BASIC COMPUTER	
Jumpers		A,C,E,G,(K),Q,T		A,B,H,L,P,S		C,D,F,M,Q		C,D,F,M,P,S	
Mapping		I/O		MEMORY		I/O		MEMORY	
k1									
X0	S1	M1	off	–	off	AEN	on	–	off
X1	S2	–	off	–	off	A3	X	–	off
X2	S3	–	off	–	off	A4	X	–	off
A3-A5	S4-S6	A3-A5	X	A3-A5	X	A5-A7	on	A3-A5	X
A6-A7	S7-S8	A6-A7	X (MSX ON)	A6-A7	X	A8-A9	off	A6-A7	X
A8-A15	S9-S16	–	–	A8-A15	X	–	–	A8-A15	X
Address range		MSX 0-3FH else 00-FFH		system dependent		300H-31FH		system-dependent	
		X2—$\overline{\text{IOREQ}}$ X1—$\overline{\text{MI}}$ $\overline{\text{RST}}$—$\overline{\text{RESET}}$ $\overline{\text{WAIT}}$—$\overline{\text{WAIT}}$ for MSX: PHI2/DIR—$\overline{\text{BUSDIR}}$ SW1 SW2		PHI2/DIR—Φ2 $\overline{\text{RST}}$—$\overline{\text{NRST}}$ $\overline{\text{WR}}$—RD/$\overline{\text{WR}}$		X∅—AEN $\overline{\text{RST}}$—RESET $\overline{\text{WAIT}}$—IOCHRDY $\overline{\text{RD}}$—$\overline{\text{IORD}}$ $\overline{\text{WR}}$—$\overline{\text{IOWR}}$		–	

*IC6, S9-S16 and R2 may be omitted

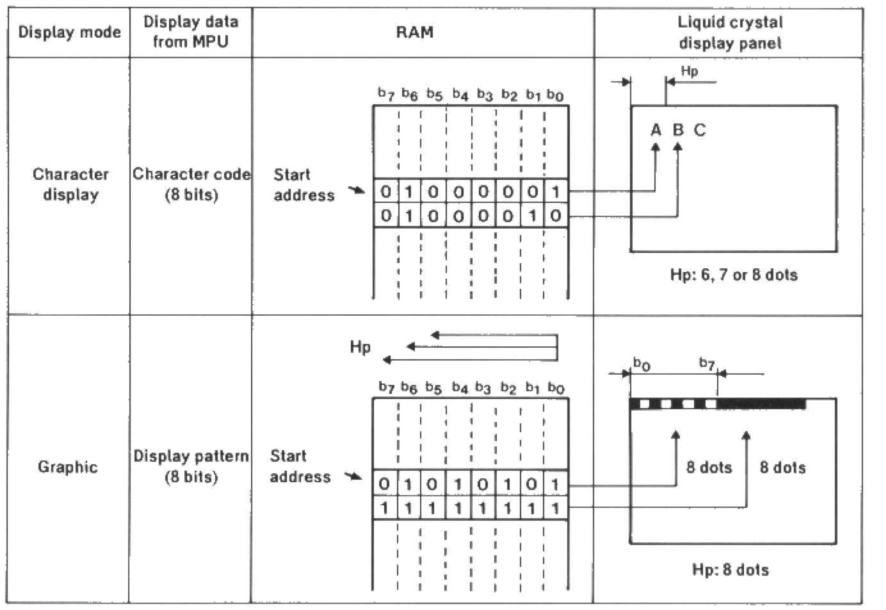


Fig. 6. Difference between character (text) display and graphic display mode as regards processing of individual bits loaded from the screen RAM.

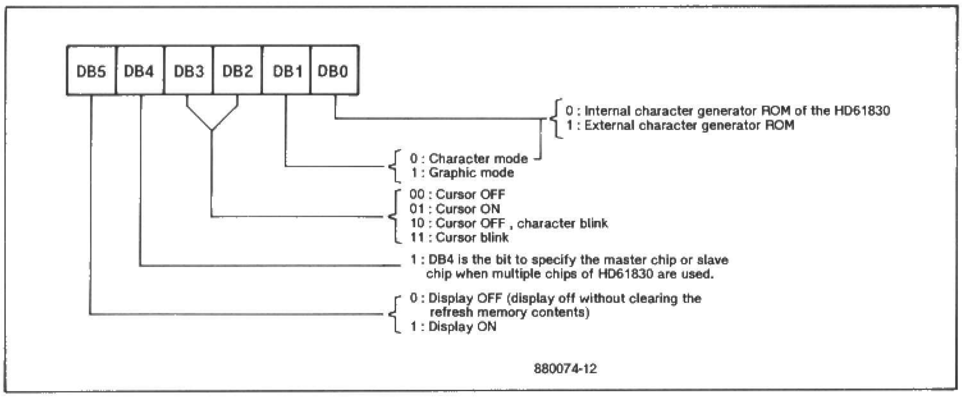


Fig. 5. Bit assignment in the MODE register of the LCD controller.

Table 3a

SLOT		←	SIGNAL DESCRIPTION
PIN NO.	**NAME**	**I/O**	**DESCRIPTION**
1	$\overline{CS1}$	O	ROM 4000 ~ 7FFF select signal (128K)
2	$\overline{CS2}$	O	ROM 8000 ~ BFFF select signal (128K)
3	$\overline{CS12}$	O	ROM 4000 ~ BFFF select signal (256K)
4	$\overline{SLTSL}$	O	Slot selected signal. ← Fixed select signal for each slot.
5		—	Reserved for future use
6	$\overline{RFSH}$	O	Refresh signal
7	$\overline{WAIT}$	I	Wait for signal to CPU (wired-OR)
8	$\overline{INT}$	I	Interrupt request signal
9	$\overline{M1}$	O	Fetch cycle signal of CPU
10	BUSDIR	I	This signal controls the direction of external data bus buffer when the cartridge is selected. It is low level when the data is sent by the cartridge.
11	$\overline{IORQ}$	O	I/O request signal
12	$\overline{MERQ}$	O	Memory request signal
13	$\overline{WR}$	O	Write signal
14	$\overline{RD}$	O	Read signal
15	$\overline{RESET}$	O	System reset signal
16		—	Reserved for future use
17	A9	O	
18	A15	O	
19	A11	O	
20	A10	O	
21	A7	O	
22	A6	O	
23	A12	O	
24	A8	O	Address bus
25	A14	O	
26	A13	O	
27	A1	O	
28	A0	O	
29	A3	O	
30	A2	O	
31	A5	O	
32	A4	O	
33	D1	I/O	
34	D0	I/O	
35	D3	I/O	
36	D2	I/O	
37	D5	I/O	Data bus
38	D4	I/O	
39	D7	I/O	
40	D6	I/O	
41	GND	—	
42	CLOCK	O	
43	GND	—	Ground
44,46	SW1, SW2	—	Insert/remove protection, if fitted
45,47	+5 V	—	+5 V power supply
48	+12 V	—	+12 V power supply
49	SOUND IN	I	Sound input (−5 dbm)
50	−12 V	—	−12 V power supply

Input and output refers to MSX computer

Table 3b Signal functions on IBM bus

Signal name			**Signal Name**
GND	B1	A1	−I/O CH CK
+RESET DRV	B2	A2	+D7
+5V	B3	A3	+D6
+IRQ2	B4	A4	+D5
−5VDC	B5	A5	+D4
+DRQ2	B6	A6	+D3
−12V	B7	A7	+D2
Reserved	B8	A8	+D1
+12V	B9	A9	+D0
GND	B10	A10	+I/O CH RDY
−MEMW	B11	A11	+AEN
MEMR	B12	A12	+A19
−IOW	B13	A13	+A18
−IOR	B14	A14	+A17
−DACK3	B15	A15	+A16
+DRQ3	B16	A16	+A15
−DACK1	B17	A17	+A14
+DRQ1	B18	A18	+A13
−DACK0	B19	A19	+A12
CLOCK	B20	A20	+A11
+IRQ7	B21	A21	+A10
+IRQ6	B22	A22	+A9
+IRQ5	B23	A23	+A8
+IRQ4	B24	A24	+A7
+IRQ3	B25	A25	+A6
−DACK2	B26	A26	+A5
+T/C	B27	A27	+A4
+ALE	B28	A28	+A3
+5V	B29	A29	+A2
+OSC	B30	A30	+A1
+GND	B31	A31	+A0

troller taking over the task of generating the dot patterns for the characters. Briefly recapitulating what has been said in the above description of the circuit, the five registers of Table 1 are either read or write locations. Four of these registers control the HD61830B, and one, LATCH, IC_{11}, whose output state determines the contrast (bits 0 to 3), the selected 4 Kbyte screen RAM (bit 6), and the selected add-on character font (bit 7).

Table 4 shows that the controller chip offers quite a few programmable functions. Its basic operation will be discussed with a few examples as guidance for further developments.

To start with, it is seen that the chip has 14 registers for storing different parameters. One register, number 14, returns the busy flag, which is logic high for about 15 μs after receipt of a controller command. The controller can not handle a new command as long as the busy flag is active. Busy can be read from the databus via register CTRL-RD (control read). It will be clear that there is very little point in using this flag in BASIC, because the relatively low processing speed of this programming language makes it impossible anyway to send a new command to the controller before this has deactivated the busy flag. Machine code programmers, however, are well advised to have the control program read and process the busy flag.

Before any character can be displayed on the LC screen, the controller must be in-

itialized. For the following description it is assumed that an LC screen Type LM40001 is used. For other types, the relevant data sheets should be examined to analyse the register assignment.

The first 4 registers in the HD61830B should always be loaded. Table 4 shows that register 0 is the mode control. The various options available are given in Fig. 5. Writing to a register is done in two passes: first, load the register number in address control-write (CTRL-WR), then write the relevant data to address data-write (DATA-WR). The BASIC listing of Fig. 9 illustrates this procedure. The subroutine starting at line 1000 loads variable DA in register CTL. The other four registers are loaded in a similar fashion.

Lines 60 to 100 in the demonstration program hold the the data for loading controller registers R0 up to and including R4. The corresponding screen settings form a usable default configuration, and are best copied for initial experiments in programming the LC screen. It is possible to read the data at the cursor address. To do this, first load the required cursor address in register 7 (LS byte) and register 8 (MS byte). Then perform a dummy read via address DATA-RD. Next, read the data 'underneath' the cursor from address DATA-RD. Any subsequent read command returns the data at the next address in the screen memory. A new dummy read operation is not required until the cursor address is altered by the control program.

When the LC screen is set to graphics mode, all graphics data to be displayed corresponds to dot information written into the screen memory. The controller is switched to graphics mode by programming a logic 1 for bit 1 in the mode register. The graphics information can then be written direct to the screen memory. Data can be loaded as separate bytes after loading the start and cursor address, similar to the procedure followed in the text mode. Before sending the databyte it is, however, necessary to call register 12 via CTRL-WR, and then write the data to DATA-WR. The dot usage of the controller is shown in Fig. 6. The listing of Fig. 9 may also help to analyse the operation of the graphics mode in further detail. Like ASCII characters, dot information can be read back from the display — write 13 to CTRL-WR, then perform a dummy

	A11	0	0
	A10	0	0
	A9	0	0
	A8	0	0
	A7	0	1
A6 A5 A4	A3 A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0	D7 D6 D5 D4 D3 D2 D1 D0
0 0 0	0 0 0 0	1 1 1 1 0 0 0 0	0 1 1 1 0 0 0 0
	0 0 0 1	1 0 0 0 1 0 0 0	1 0 0 0 1 0 0 0
	0 0 1 0	1 0 0 0 1 0 0 0	1 0 0 0 1 0 0 0
	0 0 1 1	1 1 1 1 0 0 0 0	1 0 0 0 1 0 0 0
	0 1 0 0	1 0 1 0 0 0 0 0	1 0 1 0 1 0 0 0
	0 1 0 1	1 0 0 1 0 0 0 0	1 0 0 1 0 0 0 0
	0 1 1 0	1 0 0 0 1 0 0 0	0 1 1 0 1 0 0 0
	0 1 1 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 0 0 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 0 1 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 0 1 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 1 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 1 0 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 1 1 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	1 1 1 1	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 1	0 0 0 0	1 1 1 1 1 0 0 0	
	0 0 0 1	0 0 1 0 0 0 0 0	
	0 0 1 0	0 0 1 0 0 0 0 0	
	0 0 1 1	0 0 1 0 0 0 0 0	
	0 1 0 0	0 0 1 0 0	

Fig. 7. Illustrating the compiling of a dot pattern matrix to be loaded into an add-on font EPROM.

Table 4 **HD61830B Register Overview**

Register									Data										
CTL	R/W	RS	DB7~DB4	DB3	DB2	DB1	DB0	Function	R/W	RS	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	0	0	0	0	0	Mode control	0	0	0	0	Mode data					
1	0	1	0	0	0	0	1	Vertical/horizontal character pitch	0	0	(Vp − 1) B				0	(HP-1) B		
2	0	1	0	0	0	1	0	Number of characters per line/number of bytes	0	0	0	(HN − 1)B						
3	0	1	0	0	0	1	1	Number of vertical dots	0	0	0	(NX − 1) B						
4	0	1	0	0	1	0	0	Cursor position	0	0	0	0	0	0	(CP − 1) B			
8	0	1	0	1	0	0	0	Display starting address (least significant) (Lower)	0	0	Address data							
9	0	1	0	1	0	0	1	Display starting address (most significant) (Upper)	0	0	0	0	0	0	Address data			
10	0	1	0	1	0	1	0	Cursor address (least significant)	0	0	Address data							
11	0	1	0	1	0	1	1	Cursor address (most significant) (Upper)	0	0	0	0	0	0	Address data			
12	0	1	0	1	1	0	0	Refresh memory write	0	0	Character code/bit data							
13	0	1	0	1	1	0	1	Refresh memory read	1	0	Refresh memory data							
14	0	1	0	1	1	1	0	Bit clear	0	0	0	0	0	0	0	(BN) B		
15	0	1	0	1	1	1	1	Bit set	0	0	0	0	0	0	0	(BN) B		
14	—	—	—	—	—	—	—	BUSY signal read	1	1	BF	*	*	*	*	*	*	*

read, and, finally, read the bit configuration at address DATA-RD.

Adding a character set

As already stated, the controller can use data in an external EPROM to form an additional character set. Figure 7 shows how the controller converts EPROM data into dot patterns on the LC backplane. Using the information given in the figure, a simple computer program may be written to compile a user-defined character table in the EPROM. Alternatively, build the table manually by drawing the character outlines on squared paper. A ready-programmed EPROM with two additional character sets is available as stated in the Parts List.

Reference:

[1] BASIC computer. *Elektor Electronics* November 1987, p. 24-31.

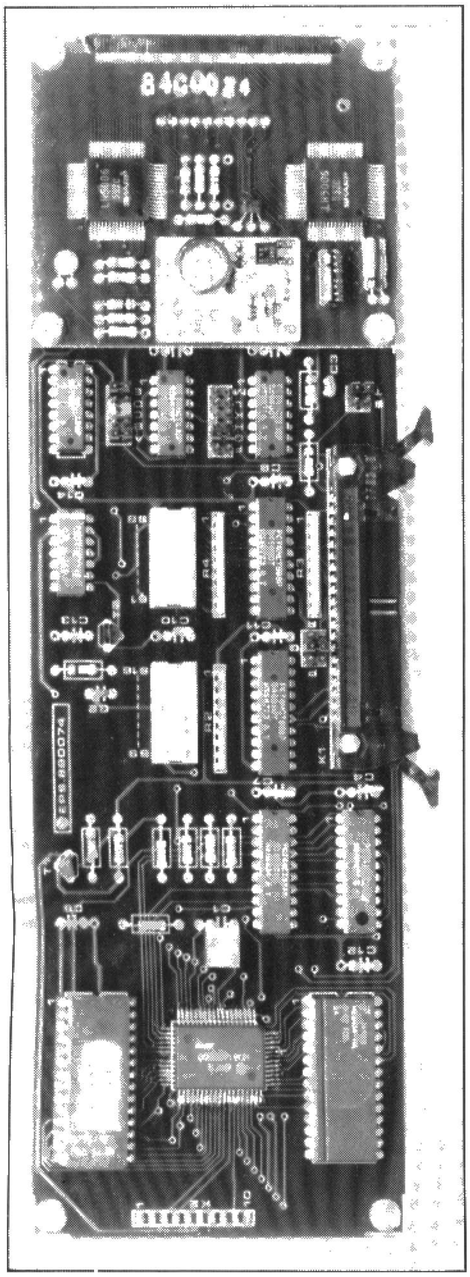


Fig. 8. Completed interface board fitted on to a Sharp LM40001 LC screen module.

```
10   REM      SHARP LM40001G WITH HD61830B CONTROLLER. 8*50 CHAR'S; 8*8 MATRIX
20   DAWR=0FFF8H
30   CTLWR=0FFF9H
40   LATCH=0FFFCH
50   REM ............................MODE, CHAR. PITCH, # OF CHAR'S, MUX, CUR
60   DATA 38H
70   DATA 77H
80   DATA 49
90   DATA 31
100  DATA 7
110  XBY(LATCH)=8: REM .......................................CONTRAST
120  REM ................................................INITIALIZE HD61830B
130  FOR CTL=0 TO 4
140     READ DA: GOSUB 1000
150  NEXT CTL
160  REM .........................................SET DISPLAY STARTADDRESS
170  STRTADR=0: GOSUB 2000
180  REM ..................................................SET CURSORADDRESS
190  CURADR=0: GOSUB 3000
200  REM .....................................................CLEAR DISPLAY
210  GOSUB 4000
220  REM ..................................................SET CURSORADDRESS
230  CURADR=0: GOSUB 3000
240  REM .....................................................WRITE MESSAGE
250  CTL=0CH: REM ...CHARACTER CONTROL
260  FOR X=0 TO 255
270  DA=X: GOSUB 1000
280  NEXT X
290  STOP: REM ............................STOP BEFORE GRAPHICS DEMONSTRATION
300  REM .....................................................ERASE DISPLAY
310  XBY(CTLWR)=0: XBY(DAWR)=32H
320  CURADR=0: GOSUB 3000: STRTADR=0: GOSUB 2000
330  FOR J=0 TO 63: FOR I=0 TO 49: XBY(CTLWR)=12: XBY(DAWR)=0: NEXT: NEXT
340  XBY(CTLWR)=0: XBY(DAWR)=32H
350  REM ......................................................DRAW PATTERN
360  STRTADR=0: GOSUB 2000
370  FOR L=0 TO 15
380    K=0: J=31
390    FOR I=L TO L-3 STEP -1
400      IF I<0 THEN 520
410        FOR X=0 TO 7 STEP 2
420          CURADR=I+J*50: A=2**(7-X)+2**(6-X): GOSUB 800
430          CURADR=CURADR-50: A=2**(7-X)+2**(6-X): GOSUB 800
440          CURADR=49-I+J*50: A=2**X+2**(X+1): GOSUB 800
450          CURADR=CURADR-50: A=2**X+2**(X+1): GOSUB 800
460          CURADR=49-I+(J+1+X*2+K*16)*50: A=2**X+2**(X+1): GOSUB 800
470          CURADR=CURADR+50: A=2**X+2**(X+1): GOSUB 800
480          CURADR=I+(J+1+X*2+K*16)*50: A=2**(7-X)+2**(6-X): GOSUB 800
490          CURADR=CURADR+50: A=2**(7-X)+2**(6-X): GOSUB 800
500          J=J-2
510        NEXT X
520      K=K+1
530    NEXT I
540  NEXT L
550  REM ...........................................WRITE LCD IN GRAPHIC MODE
570  FOR M=0 TO 2
580    I=M*3+21
590    FOR J=16 TO 44 STEP 4
600      FOR L=0 TO 2
610        READ A
620        FOR K=0 TO 3
630          CURADR=I+L+(K+J)*50: GOSUB 800
640        NEXT K
650      NEXT L
660    NEXT J
670  NEXT M
680  END: REM ...............................................................END
800  GOSUB 3000: XBY(CTLWR)=12: XBY(DAWR)=A: RETURN
1000 REM .........................................WRITE CONTROL AND DATABYTE
1010 XBY(CTLWR)=CTL
1020 XBY(DAWR)=DA
1030 RETURN
2000 REM .........................................SET DISPLAY STARTADDRESS
2010 CTL=8H
2020 DA=STRTADR.AND.00FFH
2030 GOSUB 1000
2040 CTL=9H
2050 DA=STRTADR/256
2060 GOSUB 1000
2070 RETURN
3000 REM .................................................SET CURSORADDRESS
3010 CTL=0AH
3020 DA=CURADR.AND.00FFH
3030 GOSUB 1000
3040 CTL=0BH
3050 DA=CURADR/256
3060 GOSUB 1000
3070 RETURN
4000 REM .....................................................CLEAR DISPLAY
4010 CTL=0CH
4020 XBY(CTLWR)=CTL
4030 FOR I=0 TO 399
4040   XBY(DAWR)=20H
4050 NEXT I
4060 RETURN
5000 DATA 15,0,0,15,0,0,15,0,0,15,0,0,15,0,0,15,0,0,15,0,0,255,255,15
5010 DATA 240,255,0,15,0,15,15,0,0,15,0,0,15,0,0,15,0,0,15,0,15,240,255,0
5020 DATA 255,255,0,15,0,15,15,0,15,15,0,15,15,0,15,15,0,15,15,0,15,255,255,0
```

880074-9

Fig. 9. Graphics demonstration program for the *Elektor Electronics* BASIC computer plus LC screen interface described here (LM40001). The program halts at line 290 — type CONT to continue the graphics demo. XBY(. . .) is an output instruction, and ** stands for mathematical squaring.

INTERNATIONAL BROADCAST CONVENTION 1988

The International Broadcast Convention held in Brighton last September gave visitors a unique opportunity to see the future trends in audiovisual equipment for consumer as well as broadcaster. This year's IBC concentrated mainly on technical aspects of High-Definition Television (HDTV), which will be with us in the not too distant future. Since HDTV equipment represents professional and consumer markets worth billions of pounds, it is not surprising that many manufacturers are eager to grab whatever share they can get. Once again, however, there is the danger of the radio & TV world being split in two or even more camps owing to incompatible standards. And once again, Oriental and European electronics giants have found the UK market a fine battleground.

A report from our Technical Editor

For the thousands of professional broadcasters around the world, a visit to IBC88 at Brighton enables planning at least five years ahead in equipment expenditure. For the consumer, the show is an impressive display of the audiovisual equipment of tomorrow. The futuristic trend can be quite confusing, however. For example, the S- (super) VHS video system, for which consumer equipment has been introduced recently, hardly received attention at IBC88. Looking at the latest technology on display during IBC88, it is good to bear in mind that the industry is way ahead of the consumer market.

As already stated, this year's International Broadcast Convention focused heavily on HDTV. Although this report is not intended to give a technical background to this new TV system, a general background will be given below. High-definition television is basically a move to the 'cinema at home'. Current satellite technology and the use of improved TV standards, such as MAC, have made it possible to achieve better resolution and a more natural viewing aspect ratio by doubling the number of lines in a TV picture. The possible evolution of HDTV is shown in the simplified drawings of Fig. 1 (developments in sound technology are not shown).
The MAC transmission format is essential to HDTV. A number of research institutions have worked on the development of an extended version of MAC, HD-MAC, capable of handling the high data-rates required for HDTV pictures. Current technology enables these to be transmitted via D-MAC (important for the UK BSB project) and D2-MAC (important for the West-German and French DBS projects).

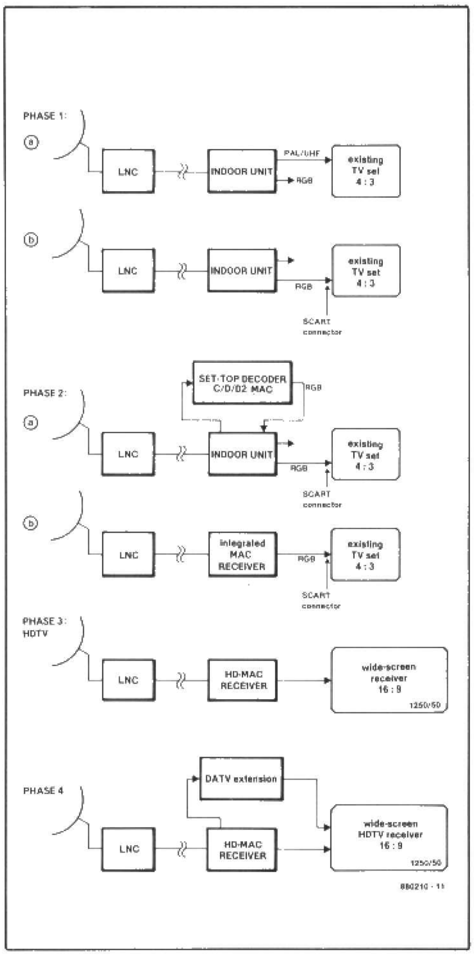


Fig. 1. Simplified drawings showing the possible evolution of television transmission techniques from the existing situation to wide screen HDTV.

Obviously, HDTV can not be introduced just like that, making consumer equipment obsolete overnight. A gradual introduction of the new standard can only go by way of initial compatibility with existing equipment. Standards converters will enable the current TV set with 4:3 aspect ratio to last well into the 1990s, alongside wide-screen types. Market researchers, however, referring to the commercial success of colour TV and the VCR, are confident of the fast acceptance of HDTV monitors and ancillary equipment, pointing out that consumers are ready to but new equipment if this offers a significant quality improvement.

East and West: the contenders

It can not be denied that the Japanese industry, headed by Sony and NHK, has been working on HDTV concepts, such as MUSE, longer than the European or North American industry. Not surprisingly, therefore, during the CCIR 1986 Plenary Assembly, it was proposed to declare the so-called 1125/60 system developed by the NHK group the world standard for HDTV. The system is based on 1125 picture lines and 60 Hz field frequency. A wide range of equipment for this standard was already available at that time, and an experiment with a Japanese DB satellite transmitting 1125/60 HDTV pictures had been successful. Two important events prevented the 1125/60 standard from being accepted, however. One was the FCC's rejection of it on the ground that it would cause total incompatibility with existing TV sets; the other was a request from

European industries and broadcasters for more time to study and develop an HDTV system of their own. With the possibility of support from the US broadcasters in mind, it is not surprising that the European, alternative, HDTV system was to pay great attention to a gradual introduction of HDTV, with compatibility, at least initially, as the first and foremost concern. Clearly, with the lost VCR battle in mind (Philips 2000 vs VHS and BetaMax), the European radio & TV industry was keen to avoid another instance of the sheer mass of Far Eastern products simply pushing aside a technically superior concept.

The CCIR was sensitive to all arguments against acceptance there and then of the 1125/60 standard, and ruled that interim studies were to be conducted before taking a final decision in 1990.

In the two years since 1986, The European industries, headed by Philips, Thomson and Bosch, and known under the name Eureka 95 Group, have not only developed their own HDTV standard, but also managed to give it global significance thanks to the keyword, initial compatibility.

In the case of the 1125/60 system, all existing standard NTSC 60 Hz equipment would require the addition of a complex standards converter. This is basically because 1125 is not a multiple of 525, the number of lines used in a standard NTSC picture. By contrast, the Eureka 1250/50 system retains compatibility because 1250 is simply two times 625 lines. An American version of HDTV meeting the FCC regulations would probably be based on 1050 (2×525) lines and 60 Hz.

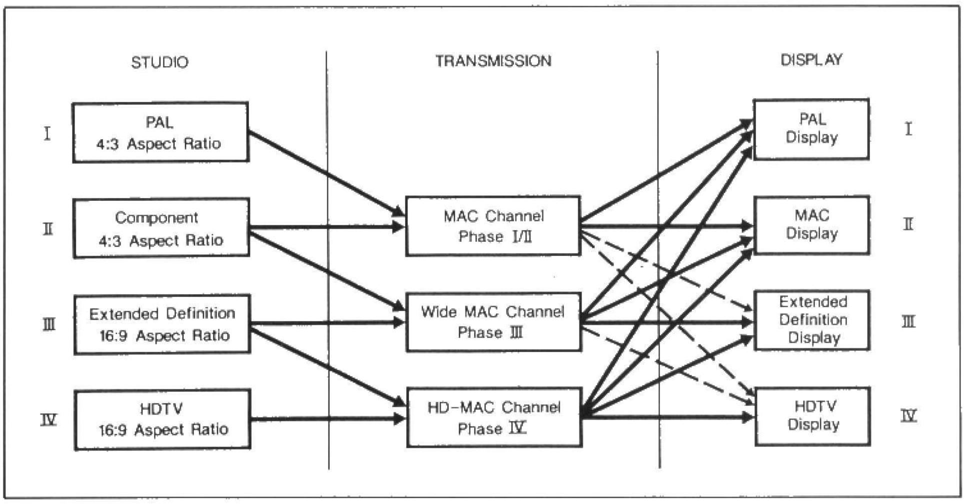


Fig. 2. Interrelation of studio, transmission and display standards (drawing *courtesy Independent Broadcasting Authority*).

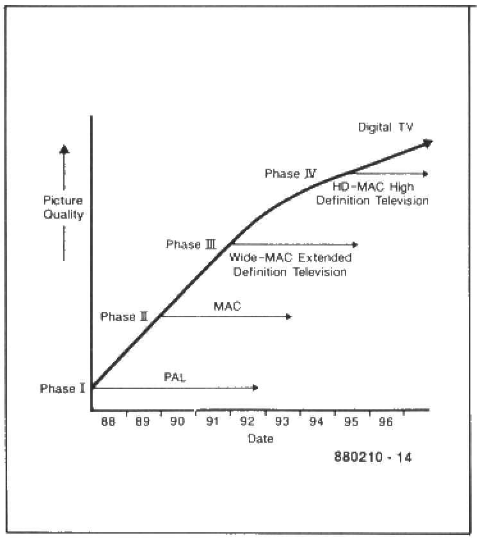
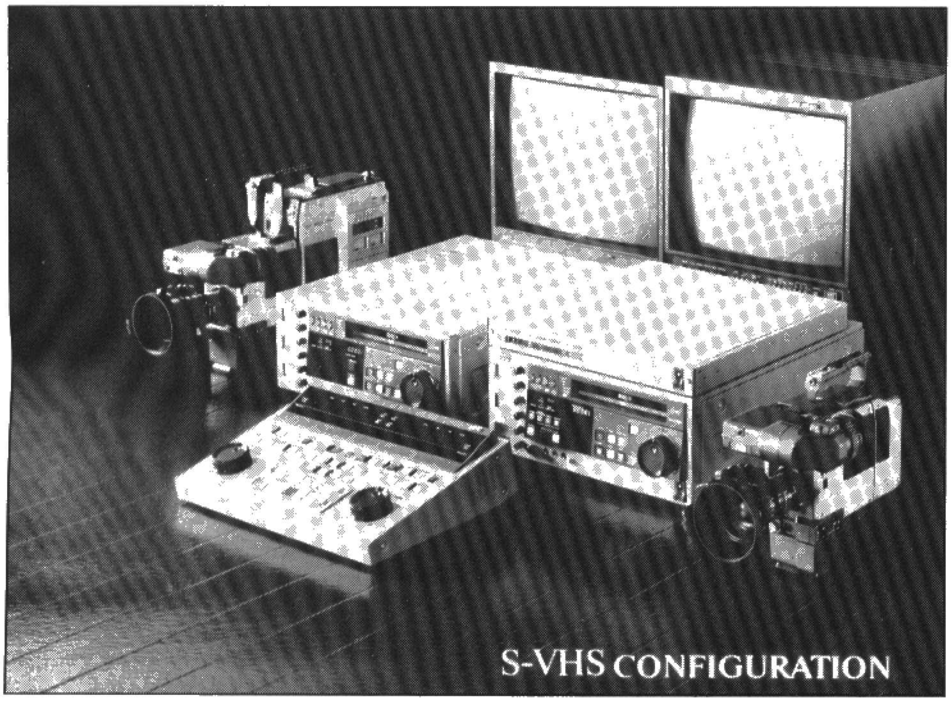


Fig. 3. Phases in the evolution of the MAC television standard, which will take TV viewers into the nineteen-nineties.

In Brighton, The Sony 1125/60 Group displayed the largest ever collection of HDTV equipment under one roof, in the sports centre of the University of Sussex, a few miles from the centre of Brighton. Demonstrations included an HDTV recording of the Genesis concert at Wembley in July 1987, displayed on a cinema-sized screen and accompanied with a digital sound track. A wide range of cameras, standards as well as field-rate and PAL/SECAM conversion equipment, was also successfully demonstrated. To show that 1125/60 HDTV pictures can be carried over considerable distances without the need for transmitters and receivers, the Sony group had arranged a live link between the Kingswest Cinema at Brighton, temporarily changed into an all-electronic cinema, and the SVC studios in London, covering a distance of about 100 km.



A line of new S (super-) VHS equipment from JVC includes a portable camcoder, an editing recorder, an editing control panel, and a 400-line, 21-inch, high-resolution PAL/SECAM monitor. Photograph *courtesy JVC Professional Products Ltd.*

Fig. 4. Logos used by the Eureka-95 group.

The link was made with the aid of a British Telecom fibre optic network, which operated at a data rate in excess of 1 Gbit/s, carrying the multiplexed luminance and chrominance components.

The Eureka Group had built a separate pavilion which housed a HDTV studio with a number of cameras, wide-screen monitors, mixing desks, and a complete telecine set-up for conversion of films to HDTV format. Also on display was British Telecom's M³VDS system. Millimetre-wave Multichannel Multipoint Video Distribution Service is an alternative to cable networking, and allows the wireless distibution of about 20 TV channels in county towns and suburban areas of large towns. A single M³VDS transmit site would cover about 8 km^2. Reception aerials are small, unobtrusive and simple to fit on the rooftop or on to a chimney. Frequencies used for M³VDS networks are in the 29 and 39 GHz bands.

Fig. 5. FDL60 CCD HDTV-compatible Telecine equipment from BTS allows cinema-format films to be sent to a HDTV studio. Photograph *courtesy Broadcast Television Systems GmbH.*

Eureka 95: philosophy and task assignment

The EU 95 HDTV Group, a joint initiative of Bosch, Philips, Thomson and Thorn EMI, aims at defining a world standard for high-definition television in the 1990s. As already noted, the full proposal for such a system is to be presented at the CCIR plenary assembly of 1990. The European unification proposals for 1992, the planned use of high-power DB satellites and the DMAC and D2MAC transmission standards are important factors that have spurred electronics manufacturers into getting together in a serious attempt to develop a compatible HDTV system that does not make existing consumer equipment obsolete overnight. Interestingly, the C-MAC transmission standard, used by the EBU, and of particular interest for the Scandinavian countries, is not mentioned in the context of Eureka HDTV.

To maximize the power of the group, each participant is assigned a particular task in a Project Group — see Table 1.

The total workload of the workgroups is defined by discipline rather than by systems or components, and comprises system studies, development of prototypes, and definition of key components.

Clearly with the potential of the North American market in mind, the EU 95 HDTV group will also study the possibility of standards conversion to and from 1050 lines/60 Hz.

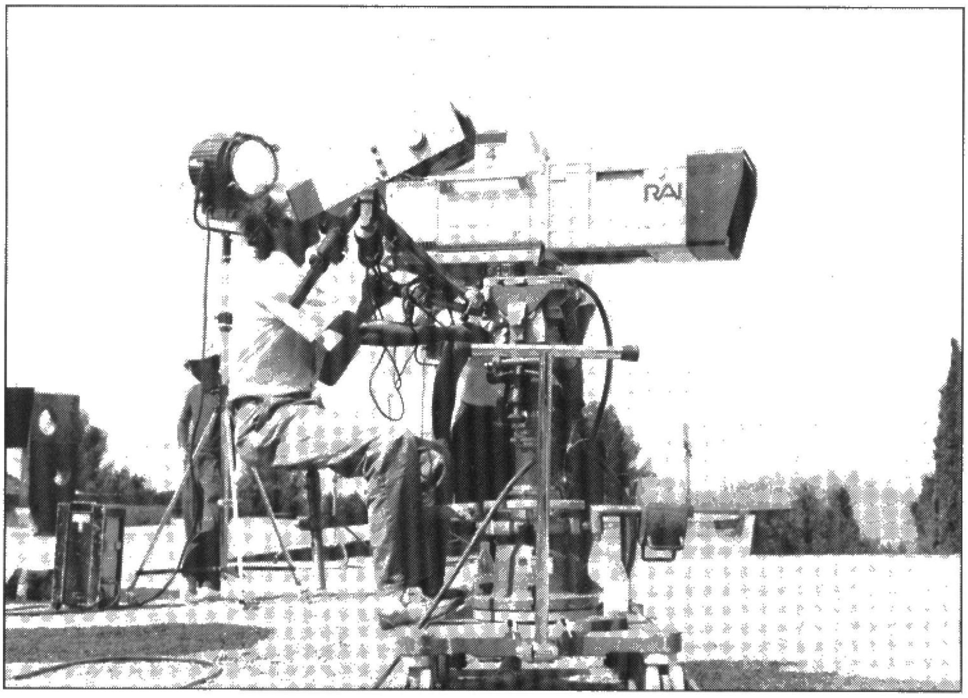


Fig. 6. Radio Televisione Italia has been appointed Project Leader of the Programme Material Group in the Eureka 95 HDTV consortium. The photograph shows the KCH 1000 flexible-standard HDTV camera in use by a RAI camera crew. Photograph *courtesy Broadcast Television Systems GmbH.*

More interesting novelties

ETEL (European Television Encryption Limited) is a new company, jointly owned by General Instrument Corporation (GIC) and British Satellite Broadcasting Limited (BSB). At IBC88, ETEL presented the basic outlines of the Eurocypher System, which is of particular interest for the BSB direct-broadcast project. As shown in Fig. 7, Eurocypher comprises a system of computers and software, encryption hardware and modules built in, or attached to, the consumers' satellite receivers. The Eurocypher system has been derived from GIC's VideoCipher system, which is the *de facto* market standard for satellite-TV encryption in the USA. ETEL is also co-ordinating work on yet another conditonal access system, Eurocrypt, which is said to be a completely new concept.

The **BBC Engineering Department** showed some interesting new developments at IBC88, and staff members delivered papers on these during the Programme of Technical Sessions.

Table 1.

Eureka 95 HDTV: Project groups

Working group	Project leader	Keywords in task description
1. Fundamentals of picture and sound	CCETT	Picture quality assessment. Colorimetry. Test pictures.
2. Production standards and standards conversion	Thomson	Studio standards conversion. MAC to PAL, MAC to SECAM conversion
3. Studio Equipment	Bosch	50 Hz HDTV equipment. Camera technology
4. Transmission	IBA	Satellite broadcasting of HD-MAC. Studio, inter-studio and uplink networking.
5. HD-MAC encoding decoding	Philips	Encoding/decoding hardware and software for transmission & reception of HDTV via a MAC channel.
6. Display standard and up-conversions	BBC	Definition of dis- play requirements. for 1250-line HDTV. Direct-view CRTs and projection systems.
7. Receivers	Ferguson	Practical receivers based on results of studies in Working Groups 5 and 6. Development of 16:9 aspect ratio CRTs, a MAC chip set, D-A and A-D converters.
8. Carriers	Philips	Modulation techniques for conumer-oriented carriers (media). HDTC VCRs, Video disc player. Electronic still picture.
9. Programme Material	RAI	High-quality programme material for HDTV demonstrations.
10. Bit-rate reduction	Thomson	Digital video technology. Interface with RACE Main programme. Digital inter-studio links.

Eureka 95 HDTV Participants

Belgium:
Barco Industries

France:
Angénieux
Captain Vidéo
CCETT (TDF & France Telecom)
Océanic
SFP
Thomson S.A.

Finland:
Nokia

Federal Germany:
Forschungsinstitut der DBP beim FTZ
Fuba
Greatz-Nokia
Grundig A.G.
Heimann GmbH
Heinrich-Hertz Institut
Intermetall
Robert Bosch GmbH
Schneider
Technische Universität Braunschweig
Universität Dortmund

Italy:
RAI
Seleco

Holland:
NV Philips Gloeilampenfabrieken

Sweden:
Swedish Telecom Radio

Switzerland:
Kudelski

United Kingdom:
BBC
British Telecom
IBA
ITV Association
Quantel
Rank Cintel
Ferguson

The Eureka 95 HDTV Directorate is formed by:
Robert Bosch GmbH, Philips International BV and Thomson Consumer Electronics.

Active line rotation (ALR) of PAL signals is a scrambling technique that closely resembles component rotation used in the MAC system. Figure 8 shows that active-line video information is cut and rotated so that the portion extending beyond the end of the line is transferred to the space at the beginning of the line. The degree of security offered by ALR is relatively high, because cut-points can be positioned at many different points throughout the active-line period, and can be changed on a line-by-line basis. Although ALR is a relatively complicated method of scrambling, it requires only small storage devices in the decoder. A purely analogue implementa-

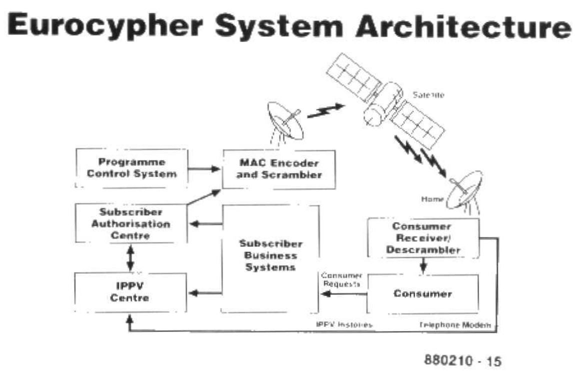
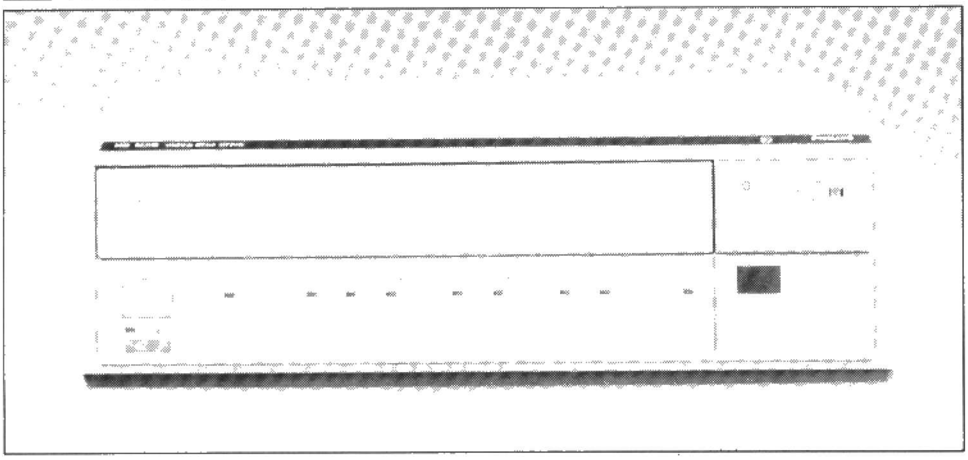


Fig. 7. ETEL (European Television Encryption Ltd.) will develop and co-ordinate the conditional access system to be used for the BSB direct broadcast venture.



As part of the Eureka HDTV project, Philips have developed an HD-MAC optical video disc drive based on a solid-state laser. The player, which was first demonstrated during IBC88, is capable of delivering stable HDTV pictures (1250/50/2:1) as well as normal TV pictures (635/50/2:1) in the new 16:9 wide screen picture format. Interestingly, the prototype shown at IBC88 had a MAC decoder circuit based on Intermetall's chip set. Advance information; photograph *courtesy Philips.*

tion of ALR could be based on CCD devices. Experimental ALR scrambled signals have been broadcast from the BBC-2 transmitter at Crystal Palace on a number of occasions since initial tests in August 1986. The demonstration of ALR equipment on the IBC stand of the BBC gave convincing results: an absolutely unintelligible picture in the absence of the descrambler!

The BBC also showed their progress in the development of a Radio Data System (RDS), whose operation and general background was covered by two papers delivered during the Technical Sessions at IBC88. RDS is basically a radio paging system that aids VHF broadcast listeners in vehicles in staying tuned to a particular programme, e.g. Radio 4, irrespective of their actual position. RDS also offers interesting possibilities for selective transmission of traffic information and emergency calls via local VHF transmitters. A local radio station (for example, Radio Kent) which is about to make a travel announcement signals this intention to the central RDS computer via an existing data network that links studio centres. The RDS computer then determines which local transmitters in the area of interest are to transmit the RDS information. RDS-compatible car radios so programmed will then switch from, say, the Radio 2 programme, to the local radio station, and convey the travel news to the driver.

The RDS system has been developed in collaboration with other European broadcasters, and uses a subcarrier at 57 kHz in the baseband spectrum shown in Fig. 9.

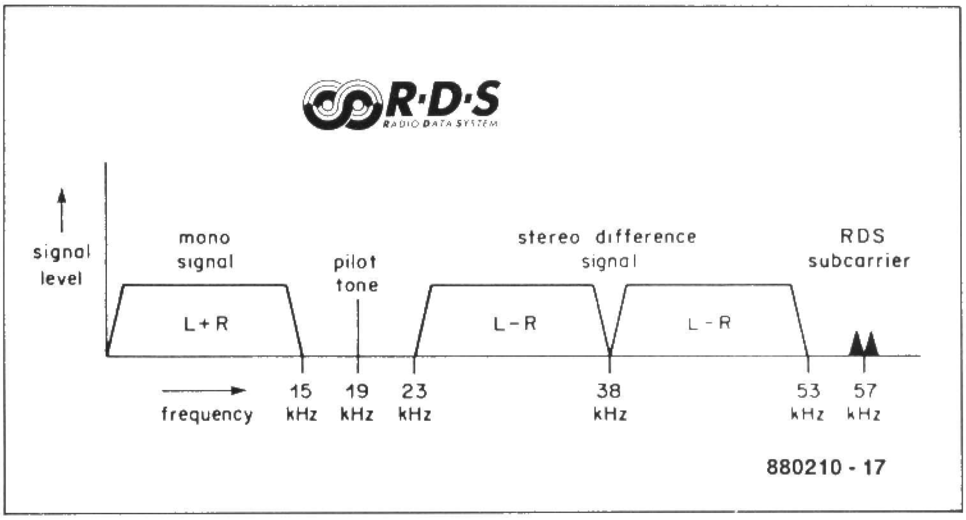


Fig. 9. Baseband spectrum of the stereo multiplex signal with the new RDS (radio data system) service that will aid listeners with suitably equipped FM receivers to find the station of their choice more easily. RDS was sucessfully demonstrated on the BBC stand during IBC88.

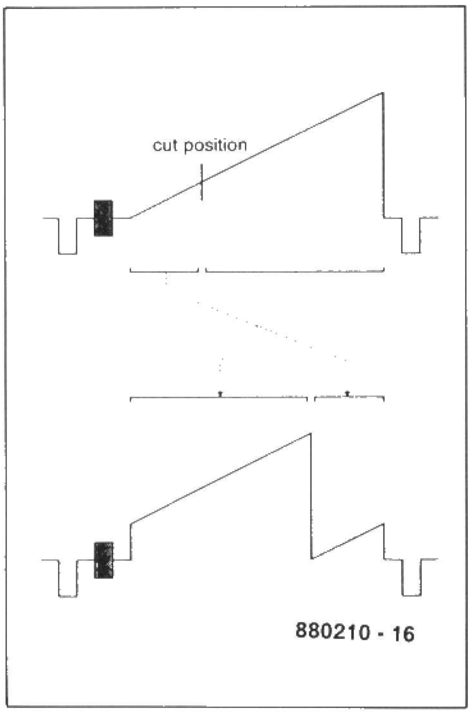
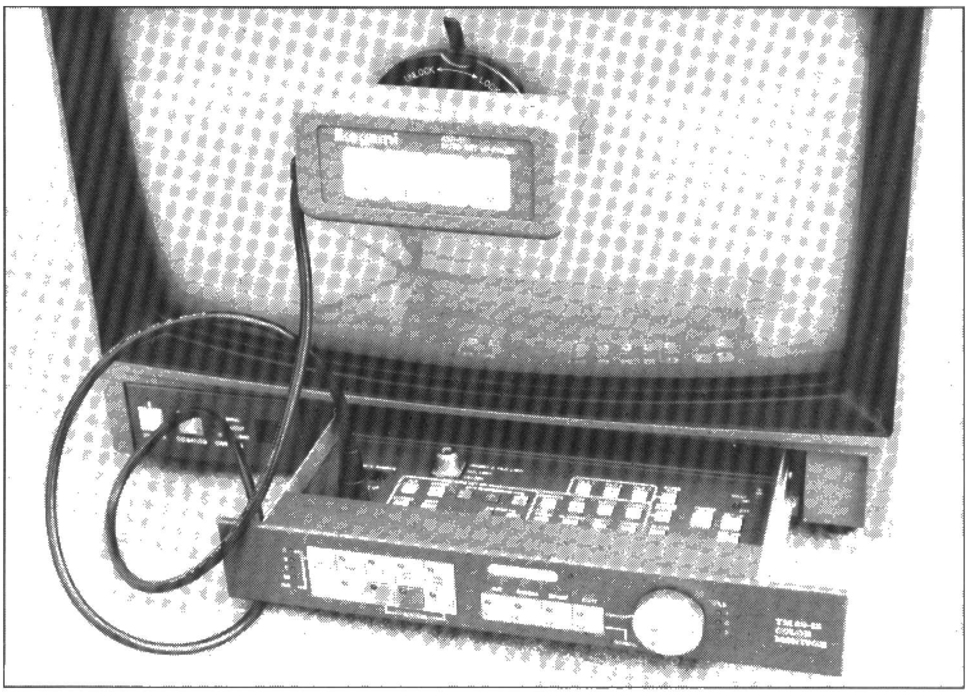


Fig. 8. Active line rotation is a new method of TV-picture scrambling developed by the BBC Engineering Department.



Ikegami series-15 colour monitor with a digital control system plus auto set-up probe for automatic setting of brightness, chroma and contrast to a referenced level. Photograph *courtesy Ikegami Electronics U.K.*

PITCH CONTROL FOR CD PLAYERS

In general, only professional compact-disc players are provided with a pitch control. Domestic types so equipped are few and far between, and are also pretty expensive. A circuit is described here that makes it possible for a pitch control to be added to most CD players at a fraction of the cost of a professional unit.

Correct operation of a CD player is ensured by a central, crystal-controlled clock operating at 11.2896 MHz. In the block diagram of a typical CD player—see Fig. 1—this clock is contained in the digital filter chip (SAA7220), but the crystal is external to this IC. The clock controls not only the data processing, such as decoding, error correction, and digital-to-analogue conversion, but also the drive motors.

In CD players less sophisticated than the Philips CD960 (used for Fig. 1), a digital filter is not used and the crystal is connected to the XTAL inputs of the decoder chip (here a Type SA7210).

For the present purposes, it is fortunate that all the circuits of a CD player continue to operate correctly if the clock frequency is altered, although the motors will run faster or slower, depending on whether the frequency is increased or reduced. In principle, therefore, it is fairly simple to alter the speed of the disc drive motor, and thus the pitch of the sound output.

According to most manufacturers, the clock frequency should be within ±10% of the nominal value, but trials in a number of CD players have shown that much greater tolerances are permissible. At very large deviations, however, some special functions, such as skip and search, fail to operate correctly. In the proposed circuit, the clock frequency may be varied between 9 MHz and 13 MHz without any detrimental effects on the electronic circuits in the player.

Basically, all that is required is to remove (unsolder) the crystal from the appropriate printed-circuit board in the CD player and replace it by the coaxial cable

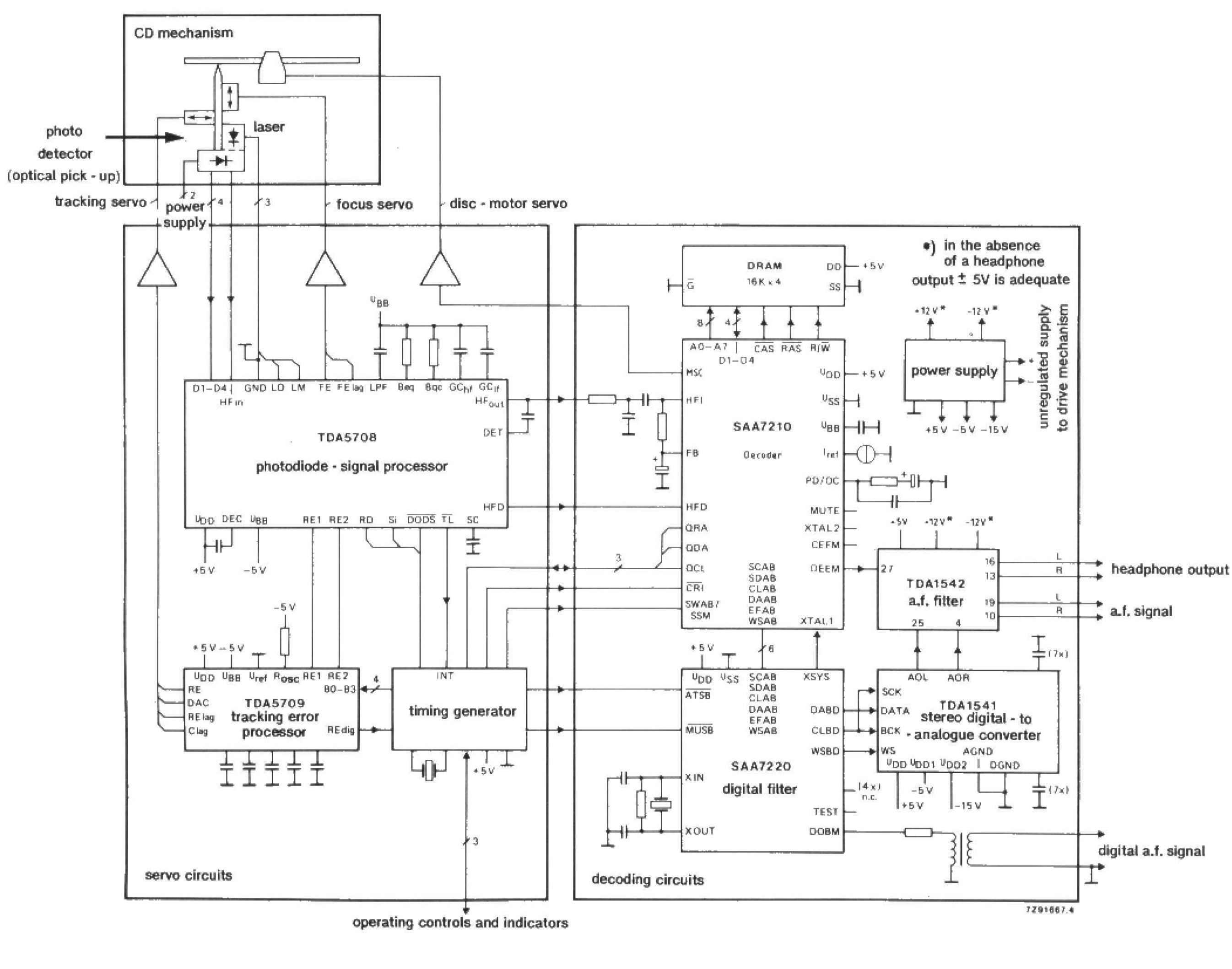


Fig. 1. Block diagram of typical CD player (Philips CD960).

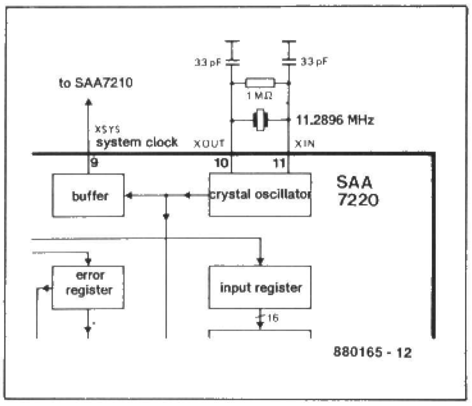


Fig. 2. Detail of the clock oscillator in the digital filter contained in Fig. 1.

from the proposed pitch control. The oscillator circuit of a typical CD player is shown in Fig. 2. It should be noted that **replacement of the crystal invalidates the initial manufacturer's warranty.**

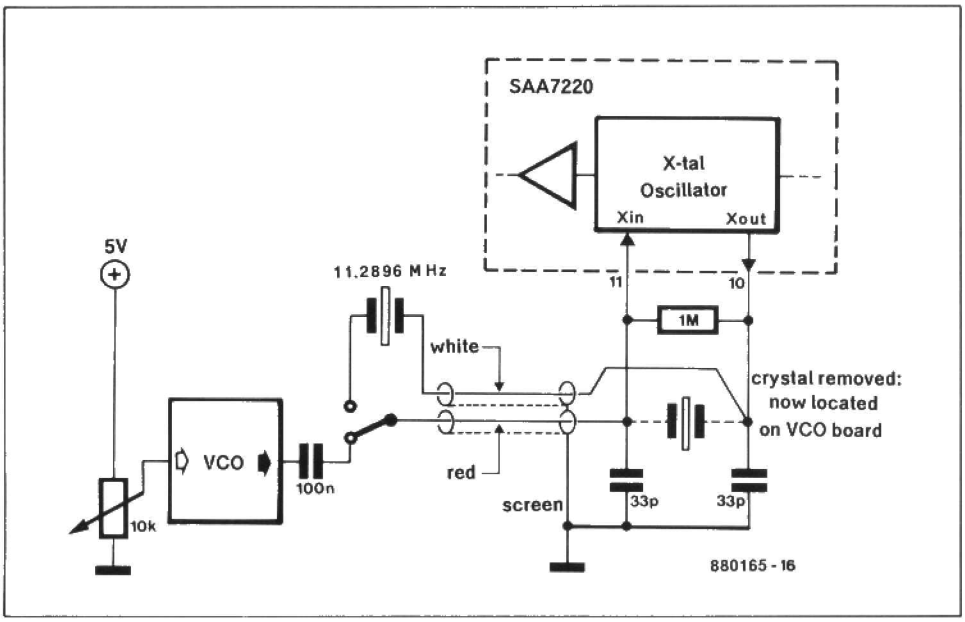


Fig. 3. Many professional CD players use this simple circuit to obtain pitch control.

PLL synthesizer

In professional CD players fitted with pitch control, the variable clock frequency is derived from a simple, free-running voltage-controlled oscillator—VCO—in which the voltage is varied with the aid of a potentiometer, as shown in Fig. 3. When the VCO is in circuit, the frequency, and thus the speed of the disc drive motor, may be altered by turning or sliding the potentiometer. Note that this circuit is provided with a switch that allows instantaneous return to the original crystal frequency when required.

This type of circuit has some drawbacks, however: owing to temperature drift, the VCO is not very stable; and the speed variation can not be controlled accurately because of the lack of an indicator.

The proposed circuit, therefore, has been enlarged and enhanced as may be seen from its block diagram in Fig. 4 and its circuit diagram in Fig. 5.

The circuit is based on a phase-locked-loop (PLL) synthesizer. The reference oscillator of the synthesizer is driven by the crystal removed from the CD player. The frequency of the VCO is compared constantly with that of the reference oscillator and made to keep in step with it. This is effected by dividing the reference signal by 400 and the VCO signal by a factor of between 320 and 460. Any deviation of the VCO frequency results in an appropriate correction in the phase comparator. A LED lights when the PLL is not locked. With the PLL locked, operation of the CD player is just as accurate

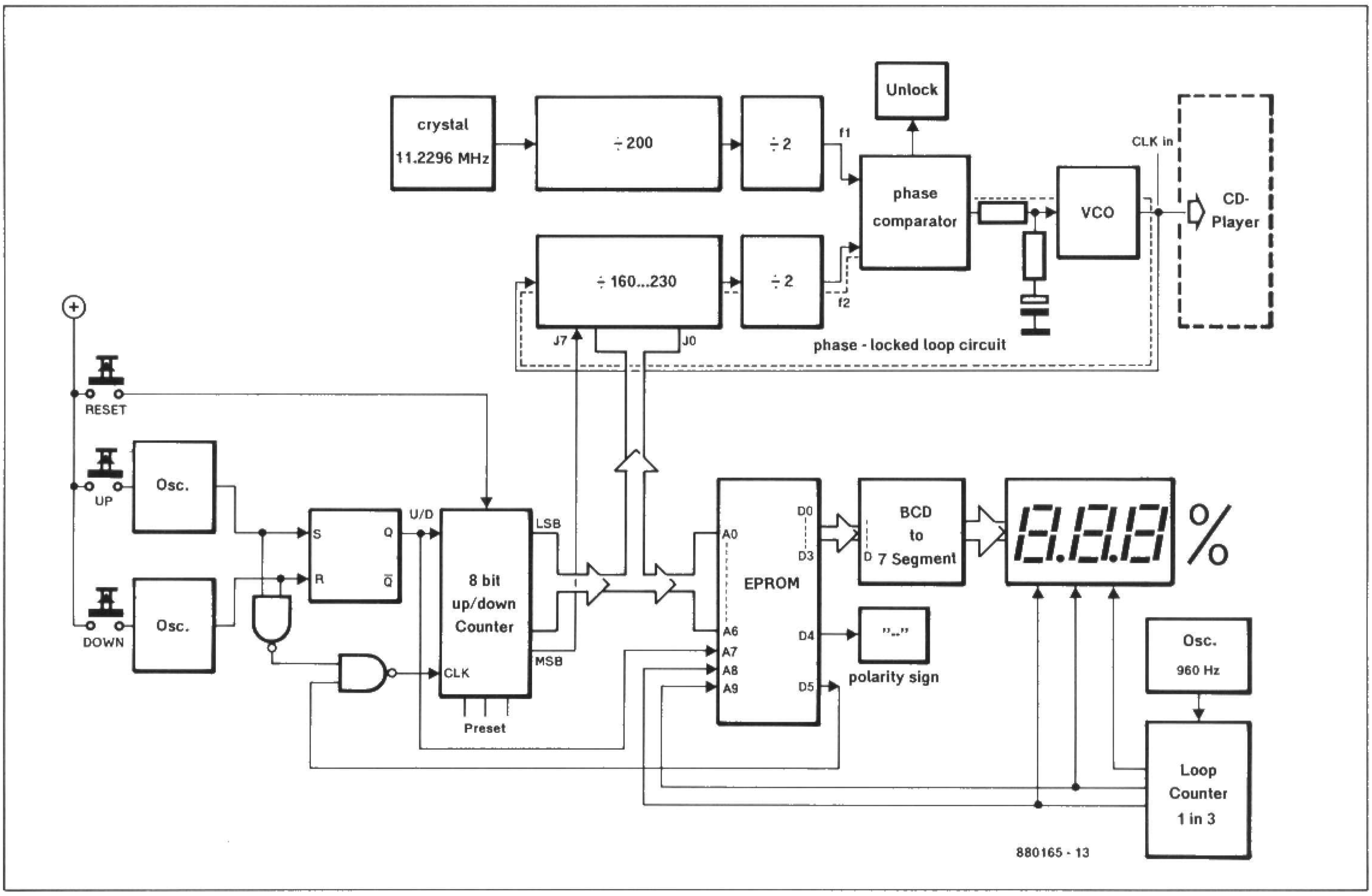


Fig. 4. Block diagram of the pitch control unit.

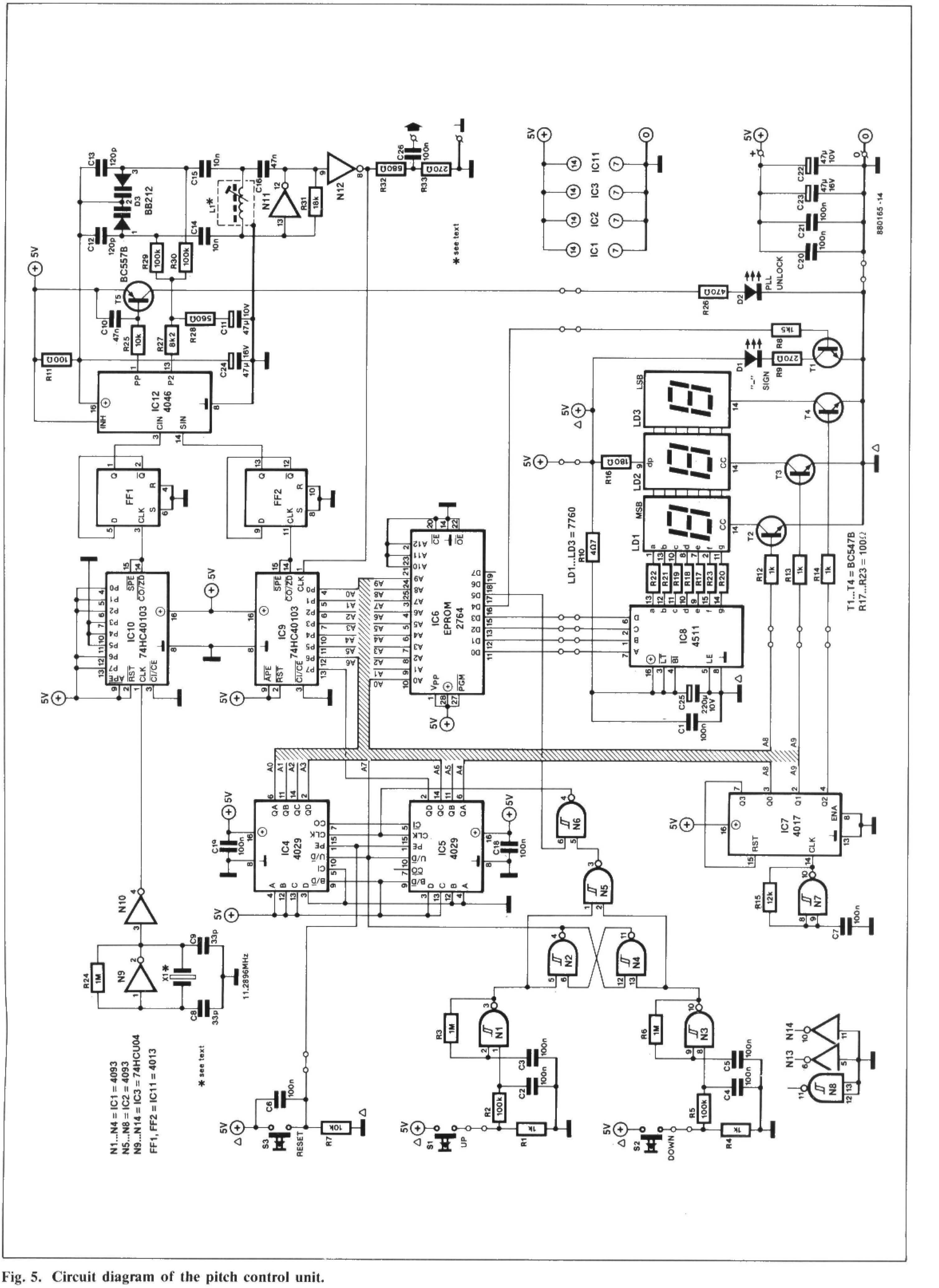


Fig. 5. Circuit diagram of the pitch control unit.

and stable as before the crystal was removed from its original position.

Even when the PLL is not locked, however (indicated by a LED lighting), nothing detrimental happens: the VCO then operates in a free-running mode.

The programmable divider in the feedback loop of the VCO is set with the aid of miniature pushbutton switches that control an 8-bit up-down counter. The output data of the counter may vary the divide factor of counter IC_9 between 160 and 230.

The up-down counter is also connected to EPROM IC_6. This circuit is used as a decoder driving a three-digit display. The binary output of the up-down counter is converted into 0.5% steps on the display: 11001000 represents 00.0%.

Starting from a counter output of 11001000 (decimal 200), each change of 1 bit (more or less) causes a display shift of 0.5%.

The EPROM also limits the frequency shift to −20% and +15%, because bit 6 (D_5) at its output is fed back to block the up-down counter.

The EPROM also provides polarity indication: when the up-down counter output decreases, diode D_1 lights to show the minus sign.

Since the EPROM content is divided into three, a Type 4017 IC is used for multiplexing the three display segments.

Apart from main dividers IC_9 and IC_{10}, there are two bistables in IC_{11} that serve as binary scaler. These dividers ensure that the phase comparator is provided with true square-wave pulses to prevent any problems in the phase comparison.

The circuit of IC_{12} is shown in Fig. 6. The time constant of network R_{27}-R_{28}-C_{11} at pin 13 determines the regulating

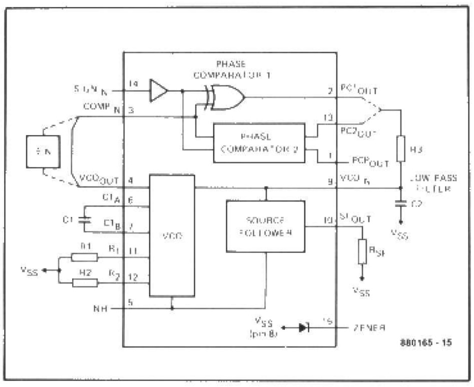


Fig. 6. Internal circuit of phase comparator chip Type 4046.

time of the PLL. The regulating voltage is applied to double variable-capacitance diode D_3 in the VCO circuit.

The frequency of the VCO is determined by L_1-C_{12}-C_{13}-D_3. The oscillator is basically the same as the original crystal oscillator.

The oscillator signal is fed via inverter N_{12} to the output terminal and also to divider IC_9. The potential divider at the output, R_{32}-R_{33}, provides level matching and forms a low-pass filter with the capacitance of the coaxial cable and the capacitor at the XIN terminal of the SAA7220 in the CD player. Both these measures ensure that the signal at pin 11 of the SAA7220 is a true sine wave at a level of about 1 V_{pp}.

Practical considerations

A phase-locked loop synthesizer on CMOS ICs and operating over the range 9—13 MHz can be constructed properly only on the carefully designed PCB shown in Fig. 7. It is essential that the supply lines are decoupled properly as, for instance, those to the VCO by R_{11} and C_{24}.

Since the pitch control circuit draws up to 220 mA, it will normally not be possible to take the power supply from the CD player. A simple +5 V supply will do, however.

Note that because of the high frequencies the dividers in the PLL should be HC or HCT CMOS types; all other ICs may be standard CMOS.

The simple content of the EPROM is given in Fig. 9 to enable constructors to program this device themselves.

Coil L_1 consists of 16 turns enamelled copper wire of 0.2 mm diameter on a Neosid Type 7F1S former. The ends of the winding are soldered to two of the five pins on the base of the former, which themselves are soldered to the PCB.

The inductor is trimmed with the aid of a non-conducting trimming tool. The core is situated correctly if UNLOCK diode D_2 does not light at the extremes of the frequency range (+15% and −20%).

It is best, however, to trim the inductor with the aid of a frequency counter. It is then possible to make the readings on the 3-digit display (in %) and on the counter (in MHz) equal. If the PLL is not locked properly, the reading on the counter becomes unstable and D_2 will light.

With L_1 trimmed correctly, the regulating voltage at pin 13 of the phase comparator must be about 0.5 V at +15% frequency shift, and around 4.0 V at −20%.

It is also possible, if a frequency counter

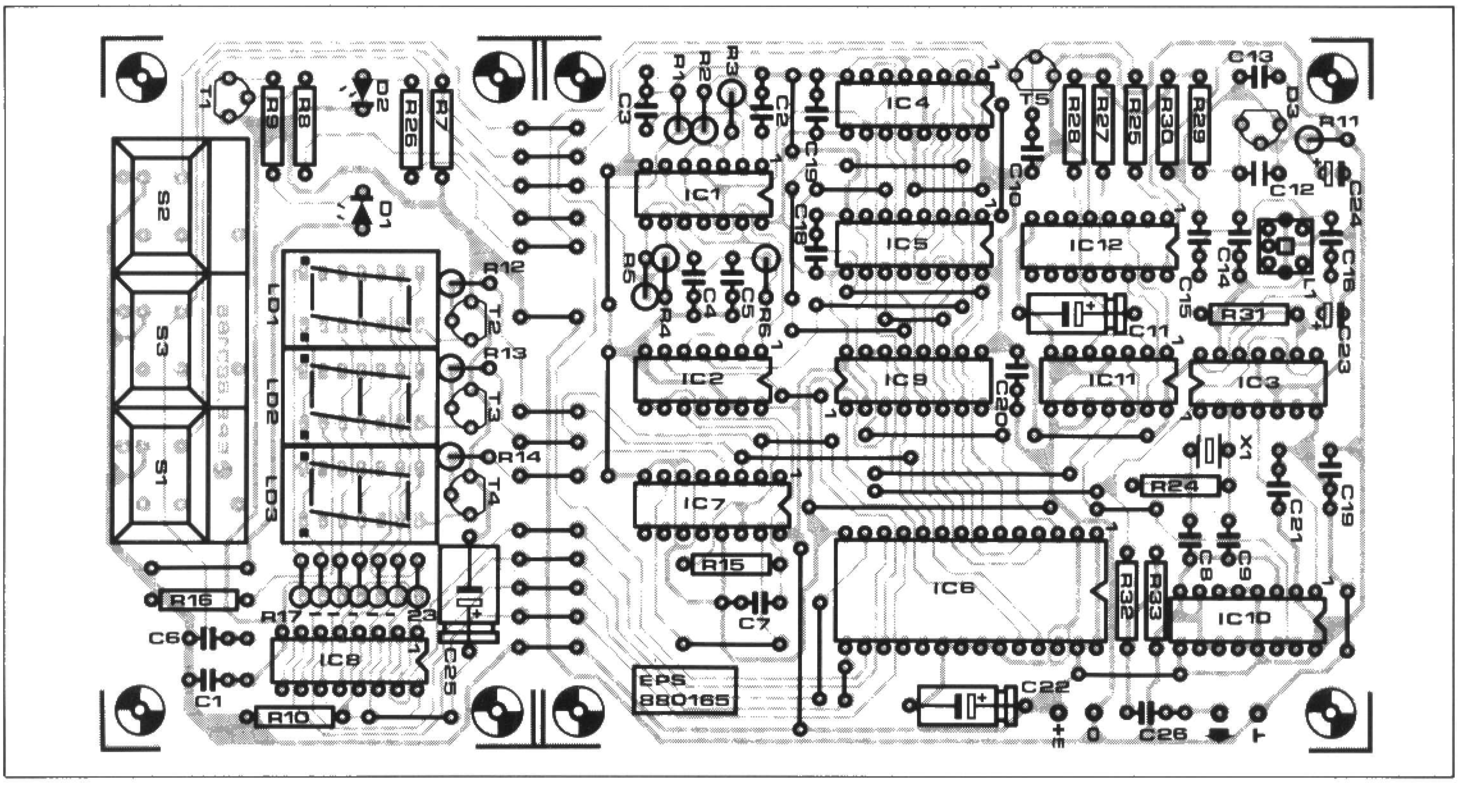


Fig. 7. Printed-circuit board for the pitch control unit.

is not available, to measure the voltage across D_2. Since that is a pulse-width modulated signal, however, an integrating multimeter must be used, set to the DC range. At both extremes of the frequency shift, the d.c. voltage across D_2 must be not greater than 150 mV.
If the varicap diode, D_3, is out of tolerance, so that the correct frequency shift can not be obtained, the values of C_5 and C_6 may be changed slightly (smaller value = higher VCO frequency). In extreme cases, it may be necessary to increase the number of turns on L_1 to 18 or even 19.

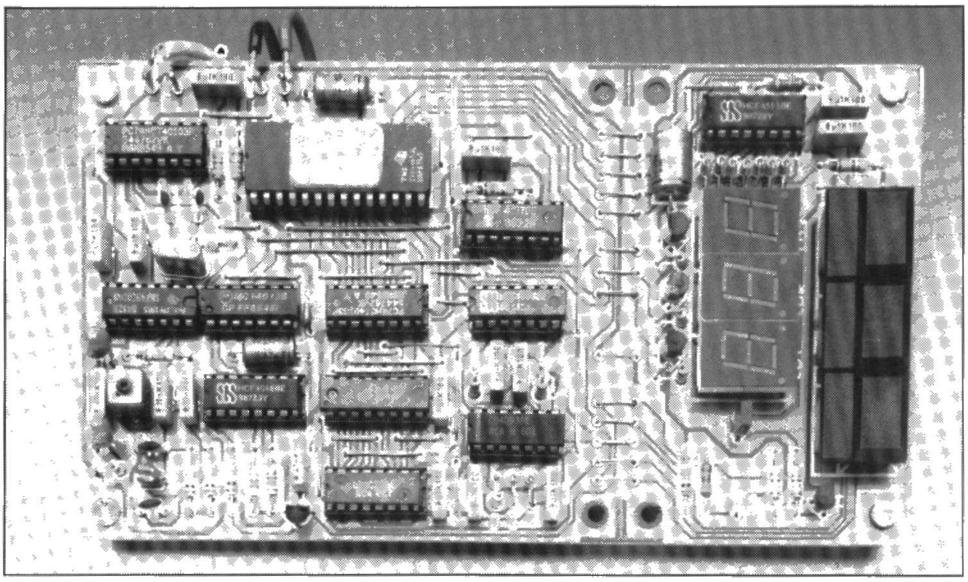


Fig. 8. The completed pitch control board.

Parts list

Resistors (± 5%):
R_1;R_4;R_{12} . . . R_{14} incl. = 1K0
R_2;R_5;R_{29};R_{30} = 100K
R_3;R_6;R_{24} = 1M0
R_7;R_{25} = 10K
R_8 = 1K5
R_9;R_{33} = 270R
R_{10} = 4K7
R_{11} = 100R
R_{15} = 12K
R_{16} = 180R
R_{17} . . . R_{23} incl. = 100R
R_{26} = 470R
R_{27} = 8K2
R_{28} = 560R
R_{31} = 18K
R_{32} = 680R

Capacitors:
C_1 . . . C_7 = 100n
C_8;C_9 = 33p
C_{10};C_{16} = 47n
C_{11};C_{22} = 47μ; 10 V
C_{12};C_{13} = 120p
C_{14};C_{15} = 10n
C_{18};C_{19};C_{21};C_{26} = 100n
C_{20} = 100n ceramic
C_{23};C_{24} = 47μ; 16 V; tantalum
C_{25} = 220μ; 10 V

Semiconductors:
D_1;D_2 = LED
D_3 = BB212⁺
IC_1;IC_2 = 4093
IC_3 = 74HCU04
IC_4;IC_5 = 4029
IC_6 = 2764
IC_7 = 4017
IC_8 = 4511
IC_9;IC_{10} = 74HC40103
IC_{11} = 4013
IC_{12} = 4046
LD_1 . . . LD_3 incl. = 7760 common-anode LED display
T_1 . . . T_4 incl. = BC547B
T_5 = BC557B

Miscellaneous:
L_1 = Neosid inductor assembly Type 7F1S⁺.
S_1 . . . S_3 incl. = Digitast switch (ITW or IIT/Schadow).
X_1 = quartz crystal 11.2896 MHz.
PCB Type 880165 (see Readers Services page).

⁺ Available from C-I Electronics • P.O. Box 22089 • 6360 AB Nuth • The Netherlands.

```
0000:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0010:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF 10
0020:  35 30 35 30 35 30 35 30  35 30 35 30 35 30 35 30
0030:  35 30 35 30 35 30 35 30  35 30 35 30 35 30 35 30
0040:  35 30 35 30 35 30 35 20  25 20 25 20 25 20 25 20
0050:  25 20 25 20 25 20 25 20  25 20 25 20 25 20 25 20
0060:  25 20 25 20 25 20 FF FF  FF FF FF FF FF FF FF FF
0070:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0080:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0090:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF 30
00A0:  35 30 35 30 35 30 35 30  35 30 35 30 35 30 35 30
00B0:  35 30 35 30 35 30 35 30  35 30 35 30 35 30 35 30
00C0:  35 30 35 30 35 30 35 20  25 20 25 20 25 20 25 20
00D0:  25 20 25 20 25 20 25 20  25 20 25 20 25 20 25 20
00E0:  25 20 25 20 25 00 FF FF  FF FF FF FF FF FF FF FF
00F0:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0100:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0110:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF 12
0120:  31 31 31 31 31 31 31 31  31 31 31 31 31 31 31 31
0130:  31 31 31 31 3F 3F 3F 3F  3F 3F 3F 3F 3F 3F 3F 3F
0140:  3F 3F 3F 3F 3F 3F 3F 2F  2F 2F 2F 2F 2F 2F 2F 2F
0150:  2F 2F 2F 2F 2F 2F 2F 2F  2F 2F 2F 21 21 21 21 21
0160:  21 21 21 21 21 21 FF FF  FF FF FF FF FF FF FF FF
0170:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0180:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0190:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF 32
01A0:  31 31 31 31 31 31 31 31  31 31 31 31 31 31 31 31
01B0:  31 31 31 31 3F 3F 3F 3F  3F 3F 3F 3F 3F 3F 3F 3F
01C0:  3F 3F 3F 3F 3F 3F 3F 2F  2F 2F 2F 2F 2F 2F 2F 2F
01D0:  2F 2F 2F 2F 2F 2F 2F 2F  2F 2F 2F 21 21 21 21 21
01E0:  21 21 21 21 21 01 FF FF  FF FF FF FF FF FF FF FF
01F0:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0200:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0210:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF 10
0220:  39 39 38 38 37 37 36 36  35 35 34 34 33 33 32 32
0230:  31 31 30 30 39 39 38 38  37 37 36 36 35 35 34 34
0240:  33 33 32 32 31 31 30 20  20 21 21 22 22 23 23 24
0250:  24 25 25 26 26 27 27 28  28 29 29 20 20 21 21 22
0260:  22 23 23 24 24 25 FF FF  FF FF FF FF FF FF FF FF
0270:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0280:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
0290:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF 30
02A0:  39 39 38 38 37 37 36 36  35 35 34 34 33 33 32 32
02B0:  31 31 30 30 39 39 38 38  37 37 36 36 35 35 34 34
02C0:  33 33 32 32 31 31 30 20  20 21 21 22 22 23 23 24
02D0:  24 25 25 26 26 27 27 28  28 29 29 20 20 21 21 22
02E0:  22 23 23 24 24 05 FF FF  FF FF FF FF FF FF FF FF
02F0:  FF FF FF FF FF FF FF FF  FF FF FF FF FF FF FF FF
```

880165 - 17

Fig. 9. Content of EPROM IC_6.

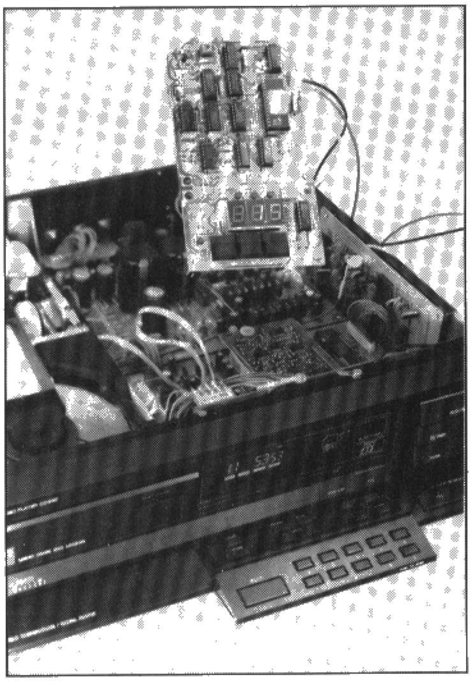


Fig. 10. Pitch control unit connected to one of the prototypes, a Philips Type CD960 CD player.

It is also possible to alter the frequency of the oscillators driving the up-down counter to some extent. With the UP or DOWN key depressed, the reading on the display increases or decreases in steps. The rate of change of these steps is determined by time constant R_3-C_3 or R_6-C_5. Increasing the value of either the resistor or capacitor makes the reading change more slowly.

If the supply voltage comes on too slowly, it may be that the value of C_6 is too low for power-on-reset. Either the value of the capacitor or that of R_7 may be increased to speed up the operation (R_7 may be increased up to 100 k).

The PCB in Fig. 7 may be cut into two to give separate synthesizer and display boards. It is then, for instance, possible to fit the display (as in the prototypes) into the CD players behind a small window to make frequent readings possible.

It is, of course, also possible to construct the pitch control unit in a self-contained metal case and connect this to the CD player via as short a length of coaxial cable as possible. The case must be earthed to obviate external radiation of the 11 MHz clock signal.

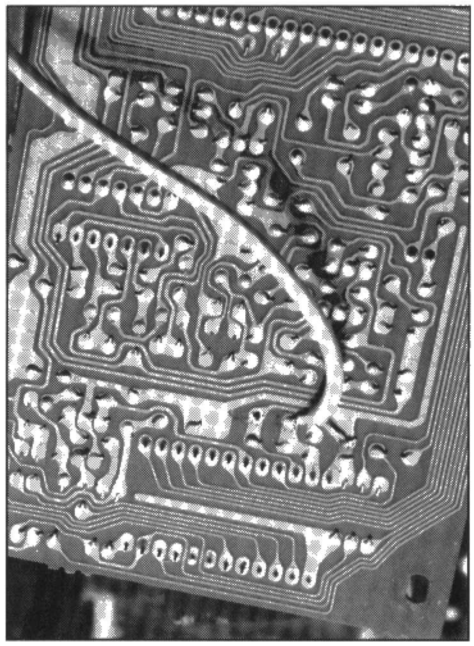


Fig. 11. Connection of the coaxial cable from the pitch control unit to the relevant board in the CD960.

NEWS

BT'S COMMITMENT TO ENTERPRISE AND EDUCATION

British Telecom has pledged that it will provide work experience for more than 1,000 schoolchildren during the coming year as part of the company's commitment to the Department of Trade and Industry's "Enterprise and Education" initiative.

The company has co-operated in providing work experience for pupils over a number of years as part of its education service activities that provide curriculum materials, in-service training and teacher fellowships.

FUTURE SUBMARINE COMMUNICATIONS SYSTEMS

A consortium of GEC-Marconi, British Aerospace, and STC has been awarded a contract by the British Ministry of Defence to carry out a feasibility study to investigate and define the communications needs of the Royal Navy's next generation of nuclear-powered submarines.

NEW ADDRESS FOR GB2ATG

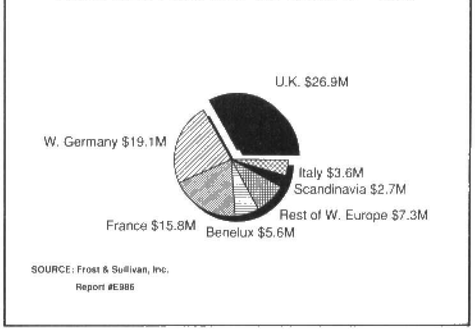
Bob Andrews, G1JZJ, who runs GB2ATG, one of the few amateur radio news broadcast services in the UK, has moved to 52, Linridge Road, Erdington, Birmingham B23 7HX.

GB2ATG is transmitted on the first and third Sunday of each month on 3.590 MHz, 14.090 MHz and 144.600 MHz.

Amateurs are invited to join the group of volunteers that transmit GB2ATG.

AUTOMATED SEMICONDUCTOR ASSEMBLY EQUIPMENT MARKET IN EUROPE

Automated Semiconductor Assembly Equipment Market in Europe, a report from Frost & Sullivan, says that Europe is becoming the world's fastest-growing market for semiconductor assembly. Chief among the factors underlying this growth in the face of traditional Japanese and American industry dominance is the rise of ASICs (application-specific integrated circuits).



EURO SATELLITE COMMUNICATIONS NETWORK COMPLETED

The last of the five European communications satellites (ECS) ordered ten years ago has just been formally accepted by the Eutelsat Organization following its launch in July and subsequent positioning in space.

The European Space Agency (ESA) ordered the five ECS satellites from British Aerospace as a follow-on from the successful BAe-built OTS satellite, which pioneered the use of satellite communications in Europe and last May began its 11th year in orbit.

$56 MILLION CONTRACT FOR MARCONI/CINCINNATI

In the largest award of this kind ever made by the United States Information Agency for any domestic or international project, a joint venture of Marconi Electronics Inc. and Cincinnati Electronics Corporation has received a contract for almost $57 million to modernize the Voice of America (VOA).

The VOA was instructed by a National Security Council directive to develop a stronger, more reliable signal, particularly to those areas of the world where information does not circulate freely.

COMPUTER-AIDED TEST EQUIPMENT

by A.W. Moore, MA

The (relatively) low cost, ease of use and flexibility of the personal computer make it eminently suitable for the control of test and measuring instruments. Many instrument and computer makers have realized this and have brought on to the market a number of parallel and serial buses to link a personal computer to one or more suitable instruments.

Not all that long ago, electronic equipment could be tested by the measuring of a few parameters (voltage, frequency, and so on) at some selected points in the circuit. Nowadays, much of such equipment is controlled by a microprocessor. Testing of this kind of equipment can only be carried out effectively by measuring the relevant parameters at many points in the circuit. Moreover, a number of these measurements needs to be taken simultaneously, owing to their interrelation.

With electronic equipment becoming more complex, instruments for testing such equipment have become more complex also and many are now controlled by a microprocessor. Such instruments are called automatic test instruments. If the internal microprocessor is controlled by an external computer, we speak of computer-aided test equipment.

Computer-aided test equipment may be dedicated, i.e., specifically designed and made for the relevant purpose, or it may consist of a PC controlling general-purpose instruments as shown in Fig. 2.

A number of internationally well-known manufacturers, such as Philips, Hewlett-Packard, Tektronix, Schlumberger and Siemens have marketed dedicated computer-aided test equipment, but these are beyond the scope of this article.

If several instruments are to be controlled by a single PC, as in Fig. 2., it is an obvious advantage if a common bus is used. Such a bus makes the set-up very flexible since it allows extra instruments to be added without much trouble.

Buses used to link the various items in a test set-up should be of a standard design to enable instruments supplied by different manufacturers to interface. A number of standards has come about as a result of co-operation between various manufacturers, and some of them have been accepted by standards organizations, such as the IEEE and IEC.

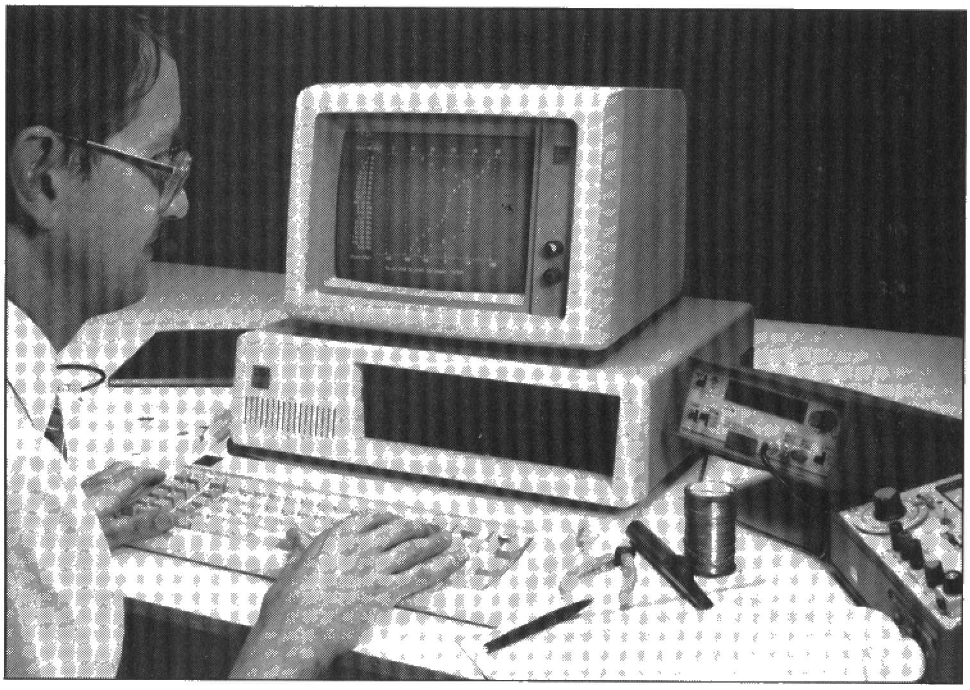


Fig. 1. Typical computer-cum-instruments set-up.

There are parallel and serial buses, as well as Local Area Networks (LANs). Some buses are used for intra-board connection, such as the STD (IEEE961) bus, the VME (Versatile Module Europe) bus, and the Futurebus (IEEE896), whereas others are used for interconnecting instruments. Of the latter, the best known is the IEEE488. The IEC625 bus incorporates the IEEE488 standard, but uses a different connector. Local Area Networks are used to connect a variety of different terminals together over a given area.

The parallel intra-instrument buses are fundamentally compatible and are usually called general-purpose interface buses (GPIBs). A GPIB allows up to 14 instruments and a computer to be connected together. The instruments may be listeners (which can only receive data) or talkers (which can only send data).

Many instruments manufactured nowadays are provided with a GPIB interface and switches that are used to set the bus address.

Sixteen active lines are used to implement the GPIB, and these are divided into three groups as shown in Table 1.

The eight data lines are bidirectional and data is transferred byte by byte.

The control bus consists of five lines. When the ATN (attention)line is ac-

tuated (by the PC), it signifies to all instruments on the bus that they must give up use of the bus and interpret the data bus as commands. The IFC (interface clear) line is asserted by the PC and used to initialize the instruments. The REN (remote enable) line is used by the PC to instruct the instruments to be ready for remote control. The SRQ (service request) line is used by an instrument to interrupt the controller to signal that it requires attention. The EOI (end or identify) line is used to indicate the end of a multiple-byte transfer or, with ATN, to force the PC to execute a polling sequence.

The transfer control lines control the transfer of data on the data bus. The DAV (data valid) line is set by a talker to indicate that valid data are present on the data lines. The NDAC (not data accepted) line is set by a listener during reading the data. The NRFD (not ready for data) is set by a listener to indicate that not all listeners are ready to accept data.

The IEEE488 standard does not define the syntax or code of messages on the bus.

Table 1

	Pin	Function	
Data bus	1	Data line	D_1
	2		D_2
	3		D_3
	4		D_4
	13		D_5
	14		D_6
	15		D_7
	16		D_8
Control bus	5	Control line	EOI
	9		IFC
	10		SRQ
	11		ATN
	12	Screen	
	17	Control line	REN
Transfer bus	6	Transfer line	DAV
	7		NRFD
	8		NDAC
	18	ground	
	19	ground	
	20	ground	
	21	ground	
	22	ground	
	23	ground	
	24	Logic ground	

Some typical available equipment

The Intepro Micro Series power supply test equipment from Limerick-based Intepro Systems is a PC expanded with a bus extender card that is complete with memory and capable of linking up to 255 plug-in instrument modules. Modules currently available include DVM, scanner, power relay, and ripple-and-noise measurement boards.

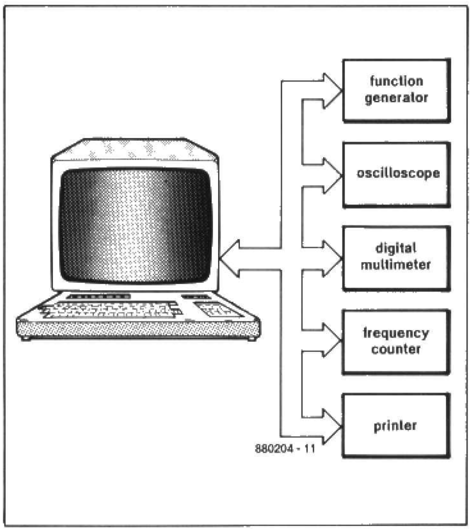


Fig. 2. Typical GPIB structure.

A full range of plug-in data acquisition and controls cards for IBM PCs and compatibles is available from Bleu Chip Technology.

Digital interface cards include the PIO-48 that has 48 programmable input or output lines. Other digital cards have optocouplers, Darlington drivers, relays and counter/timers.

The AIP-24, one of the analogue range, has 24 channels, 12-bit analogue-to-digital converter, sample-and-hold, and a programmable gain amplifier.

Other cards include multi-function cards with analogue and digital channels, thermocouple inputs and communications cards with RS232, RS422, RS485, and 20 mA standards.

ANALYSER software from Number One Systems is claimed to have become the largest selling Circuit Analysis software package in Britain with versions for the BBC and IBM (and compatible) PCs.

By simulating accurately the AC performance of a circuit design, it can give the designer confidence that circuits will behave as required, without his needing to resort to expensive test and measuring equipment while "fine tuning" a design. At higher frequencies, unanticipated effects caused by interelectrode capacitances and so on are immediately made clear.

ANALYSER performs an AC Frequency Response analysis on circuits entered into the software, and presents results in tabulated and graphical form. Analysis of gain, phase, group delay, input impedance, and output impedance versus frequency are made to give the electronic circuit designer a powerful tool with which to assess the performance of designs. Particularly useful is the ability to change one or more component values and recalculate to see what the effects of such changes are. This allows rapid solutions to design problems, and minimizes the need for breadboarding and the resultant waste of components and, more important, time.

Strays and parasitics at higher frequencies may also be taken into account. ANALYSER allows resistors, capacitors, inductors, transformers, field-effect and bipolar transistors, operational amplifiers, transmission lines and microwave striplines to be included as circuit elements. Circuits up to 60 nodes and 180 components may be analysed, and there are libraries of active components available that hold the pre-entered specifications of up to 26 of each type (bipolar transistor, FET, opamp). Data may be changed by the user to suit the types most commonly worked with.

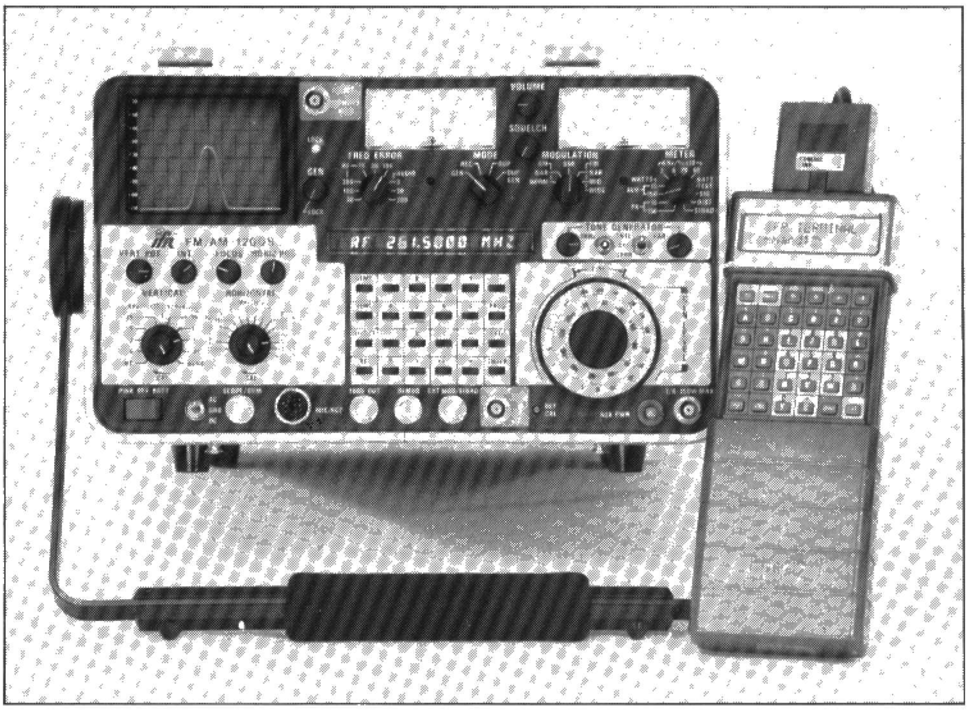


Fig. 3. PSION organizer radically changes RS-232 control & storage potential of IFR test instruments.

Although not strictly a ''computer-aided'' test equipment, Fieldtech's ORGANIZER II and COMMS LINK are of interest to note.
The ORGANIZER II takes the place of a PC as controller to drive IFR test instruments. Since the unit is little bigger than multi-function calculator, it may be used as hand-held controller that can be stored in the test-set lid when not in use.

Some useful addresses.

Amplicon Electronics Ltd
Richmond Road
BRIGHTON BN2 3RL
Telephone (0273) 608331

Blue Chip Technology
Main Avenue
Hawarden Industrial Park
DEESIDE
Clwyd CH5 3PP
Telephone (0244) 520222

Fieldtech Heathrow Ltd
Huntavia House
420 Bath Road
LONGFORD UB7 0LL
Telephone 01-897 6446

Fluke Ltd
Colonial Way
WATFORD WD2 4TT
Telephone (0923) 40511

Hewlett-Packard Ltd
Nine Mile Ride
WOKINGHAM RH11 3LL
Telephone (0334) 773100

Intepro Systems Ltd
Crescent House
77-79 Christchurch Road
RINGWOOD BH24 1DH
Telephone (0425) 471421

Keithley Instruments Ltd
1 Boulton Road
READING RG2 0NL
Telephone (0734) 861287

Number One Systems Ltd
Harding Way
Somersham Road
St. Ives
HUNTINGDON PE17 4WR
Telephone (0480) 61778

Philips Instruments
Mullard House
Torrington Place
LONDON WC1E 7HD
Telephone 01-580 6633

Schlumberger Instruments
Victoria Road
FARNBOROUGH GU14 7PW
Telephone (0252) 544433

Siemens Ltd
Siemens House
Windmill Road
SUNBURY-ON-THAMES TW16 7HS
Telephone (09327) 85691

Tektronix Ltd
Fourth Avenue
Globe Park
MARLOW SL7 1YD
Telephone (06284) 6000

NEWS

NEW COMMUNICATIONS PACKAGE FOR INFANTS

A new educational package for infant classes has been produced by British Telecom's Education Service. Entitled *Air, Land and Sea Communications*, it is designed to help teachers explore the subject of communications with 5-7 year old pupils.
Using simple language and colourful illustrations, the resource contains a wealth of factual information covering the history of the telephone from Alexander Graham Bell to the modern payphone, undersea cables and satellites.

GEC NATIONAL ONE APPROVES SUBSCRIBER RADIOS

National One, the public trunked mobile radio network run by GEC-Marconi, has given certificates of conformance to Tait Mobile Radio Ltd (T540TR), Marconi Mobile Radio (RC630) and Motorola (MC Micro), thereby approving each company's equipment for registration on the National One system.

INMARSAT IN CHINA

INMARSAT Director of Administration, Noel Isotta, and CLTC Director of Tracking, Telemetry and Command, Zong Wenxuan, recently signed a contract under which CLTC (China Satellite Launch Tracking and Control) will provide a range of services for the INMARSAT-2 Pacific Ocean Region sat-

ellite. Under the terms of the contract, CLTC, a division of China's Commission on Science, Technology, and Industry for National Defence, will provide a 24-hour dedicated tracking station in Beijing. Because of its location, this earth station will be able to cover both INMARSAT's Pacific Ocean and Indian Ocean Region satellites.

ELECTRICAL SKILLS FROM NORWAY

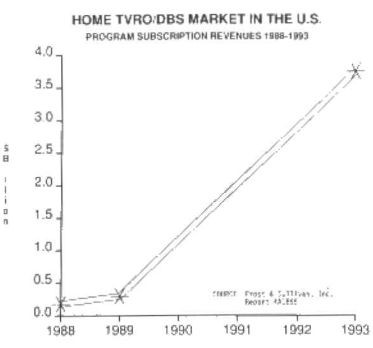
A comprehensive survey of electrical and electronics expertise offered to international markets by Norwegian specialists in this field is provided by *Norway Exports — Electrical Technology*, a publication from the Export Council of Norway. Apart from equipment and systems for power generation, transmission and distribution, the booklet coveres installation equipment, appliances and electronic products.
Amply illustrated throughout in full colour, the publication concludes with a section that lists 24 companies that play a leading role in Norway's electrical-electronics industry. It is available free of charge from
Norwegian Trade Centre • 20 Pall Mall • LONDON SW1Y 5NE.

HTEC PUTS THE IBM PC/AT ON THE VMEBUS

A new 80286-based module from HTEC is designed to combine to advantages of VMEbus power, form factor and performance with the broad software support of the IBM PC/AT. The HVME-AT286 functions as a stand-alone computer, as a single CPU system controller in a VMEbus system, or as one of several CPU elements in a multiprocessor configuration.

DBS MARKET IN THE USA

According to Frost & Sullivan Report *The Home TVRO/DBS Market in the US 1988-1993*, the pattern in the Direct Broadcast Satellite market will follow a similar course as broadcast TV, cable TV, and VCRs. Acceptance is slow at first while people get used to the idea. Then popularity soars for a number of years. Finally, demand levels off as the market reaches saturation.



AUTONOMOUS INPUT/OUTPUT CONTROLLER

A user-configurable I/O controller that gives digital and analogue interfacing power to your computer's RS232 outlet. Fast, simple to build and program, and intelligent enough to deal with up to 64 digital and 12 analogue channels, this microcontroller-driven I/O distribution box should prove invaluable in many applications where a computer runs a small or large-scale automated control job, be it industrial or domestic.

Part 1

The autonomous I/O controller described here is basically a versatile, intelligent, computer peripheral that can be connected in the bus structure proposed for the microcontroller-driven power supply published earlier this year (Ref. 1). Like the power supply, the I/O controller derives its intelligence from a Type 8751 microcontroller from Intel. The control program that resides in this chip has been written exclusively for this project in the *Elektor Electronics* design department.

Applications of the I/O box arise almost automatically when a computer is to communicate with the outside world. These applications range from essentially simple, such as the control of LED matrices, relays or electronic switches, to more sophisticated, interactive, ones including the control of motors, but also alarm, heating and air conditioning systems. The list of applications can be extended even further with PC-controlled battery chargers, light shows and audio distribution equipment. The 8-channel ADC in the system allows analogue values provided by a wide variety of sensors to be captured, stored and processed by the computer.

One button — seventy-six I/O lines

The basic operation of the autonomous I/O controller is best understood after looking at the front panel first (Fig. 1) — not a multitude of switches and other controls on this, just the on/off switch and a push-button labelled DISABLE OUTPUTS with an associated LED. There is no need for any other form of local operation, because the unit is controlled entirely by commands sent by the host computer it is connected to. There is nothing to look for at the rear side of the unit either: all that is there is the mains input socket and the 9-way D-socket that links the I/O box to the computer.

Part 2 of this article will detail the actual programming of the I/O controller with the aid of a set of commands similar to those used for the microcontroller-driven power supply. BASIC command PRINT (or LPRINT) is perfectly adequate for sending these commands via the RS232 port, so that even beginners need not worry about bus interfacing, machine language programs, or the intricacies of the microprocessor inside the host computer. Most computers provide some sort of printer output redirection facility, so that the use of the RS232 port obviates the need for complex programs to 'talk and listen' to the peripherals connected to the I/O box. There is, of course, a price to be paid for all these benefits, and this is mainly the limited speed of the system. None the less, 9600 baud should be fast enough for any of the applications mentioned earlier, since the minimum pulse duration that can be programmed on a digital output line is about 6 ms.

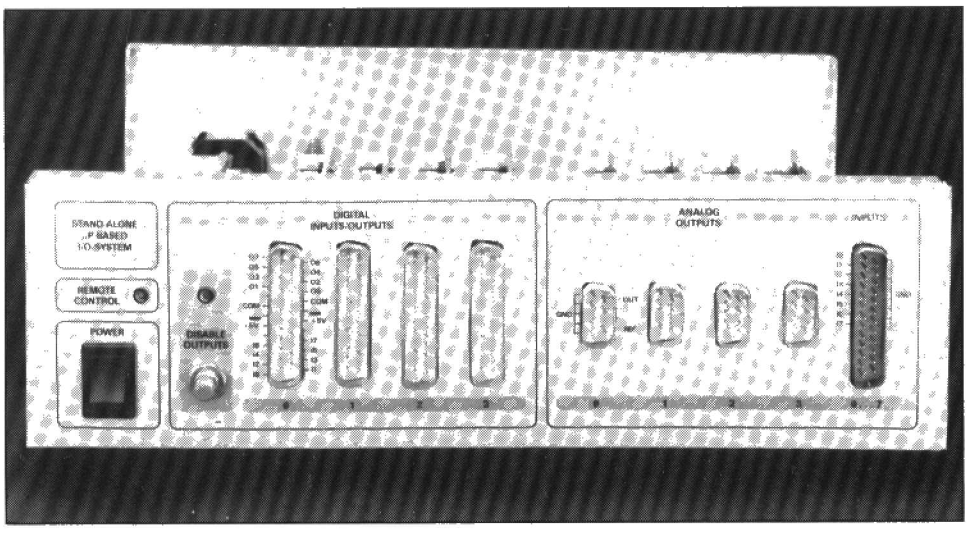


Fig. 1. Front view of the autonomous I/O controller.

Three printed circuit boards

Figure 2 shows that the autonomous I/O controller can be expanded to user requirements. The system is in principle composed of 3 types of sub-unit:

- **controller board** — this holds the microcontroller, power supply and the 10-bit analogue-to-digital converter (ADC) with its associated 8-channel input multiplexer;
- **bidirectional digital board** — this is identical to that for the 8052AH-BASIC computer (see Refs. 2 and 3);
- **analogue output board** — this is virtually identical to that for the 8052AH-BASIC computer (see Refs. 2 and 3).

There is a slight difference to note between the autonomous I/O controller and the system discussed in Ref. 3. This difference entails the maximum number of peripheral boards (digital and analogue output). In the autonomous I/O controller, there may be 0, 1, 2, 3 or 4 boards of each type, povided each is allotted a unique address (this will be reverted to in Part 2). It is not allowed to replace, for example, two analogue output boards with two bidirectional I/O boards, or the other way around.

Push-button DISABLE OUTPUTS provides a toggle function for simultaneously switching on and off all *digital* outputs. The current state of this function is indicated by a LED.

A further LED, labelled REMOTE CONTROL lights when the autonomous I/O controller communicates with the host computer.
An interesting and original feature offered by the system described here is its ability to interconnect pairs of corresponding input and output lines *with the aid of software* (command 'G'). A practical application of this feature is shown in Fig. 5 where a pair of I/O lines is used with manual switch control.

On the controller board

As already noted, the controller board holds the 'brains' of the system, the microcontroller Type 8751, and the ADC with its associated 8-way input multiplexer. The circuit diagram is given in Fig. 3.
Since the basic operation of the microcontroller, IC_1, is briefly covered in Refs. 1 and 4, the device can be treated as a 'black box' that takes care of the serial communication, the control of peripherals (digital I/O, DACs and ADC), the multiplexing of the analogue inputs, and the timing for the I/O latches. The microcontroller has on-chip RAM and ROM.

Circuit IC_2 is a supply monitor chip that ensures the correct initialization of the microcontroller at power-on. It also works as a watchdog, checking the presence of 1.1 ms long pulses on controller output line P2.0. When these pulses fail, the microcontroller is immediately reset. This is done to prevent the system generating uncontrolled signals when the supply voltage drops below the level needed for correct operation, or when the system 'hangs up' due to some internal malfunction. CPU port line P2.0 is also fed to the bidirectional digital boards. Conflicts with the watchdog are avoided by the microcontroller ensuring that $\overline{WR}$ is never activated when a pulse is sent to the watchog chip.
Diodes D_1 and D_2 determine the address, or identification code, assigned to the autonomous I/O controller — see Table 1. With 2 diodes, a choice of 4 addresses is available. This will do for most applications, given the large number of lines provided by a single autonomous I/O controller.
Analogue-to-digital converter (ADC) IC_6 is a 10-bit, 8-bit databus compatible, type from National Semiconductor. The recommended supply voltage for this chip is 5 V. For optimum conversion

Table 1.

D_1	D_2	listen	quit
o	o	144	145
f	o	146	147
o	f	148	149
f	f	150	151

o = omit
f = fit

accuracy, the reference voltage should be as high as possible, but it must never exceed the supply voltage. The reference voltage is, therefore, set to +5 V, supplied by the well-known precision stabilizer Type REF-02 (IC_5), and the supply voltage to +5.25 V, supplied by an LM317 (IC_9). The voltage difference of 0.25 V is a safety margin that should prevent fluctuations on the output voltage of the LM317 damaging the ADC.
The +5 V, −5 V and −12 V power supplies on the controller board are of conventional design and merit no further discussion.
The operation of the serial interface will be discussed in Part 2, as part of the software command descriptions.

Technical features:

INPUT/OUTPUT MODULES:

- Modular structure. Largest system configuration supports:
  32 digital outputs;
  32 digital inputs;
  4 analogue outputs;
  8 analogue inputs.
- Digital interface card has 8 buffered outputs and 8 protected inputs. Up to 4 of these modules can be bused in I/O system.
- Analogue output card has 1 output with 10-bit resolution. Output voltage span: 0 to +10.23 V, programmable in 10 mV steps. Up to 4 of these modules can be used in the I/O system.
- Analogue-to-digital converter on controller board has 8 multiplexed inputs. Input voltage span: 0 to +10.23 V. Resolution: 10 mV/LSB.
- Medium-power open-collector digital outputs are surge-protected, and can handle 50 V; 500 mA loads direct.
- Optional internal connection of digital inputs and outputs.
- Ideal for multitasking of peripherals on a single serial computer channel.

PROGRAMMING AND SERIAL INTERFACE:

- Standard serial interface and data format allow system to be controlled by almost any microcomputer or terminal. Simple line settings: 9600 bits/s; 2 stop bits; no parity bit.
- Line settings and selective addressing of peripherals is compatible with microcontroller-driven power supply. Up to 4 autonomous I/O controllers can be individually addressed via a single serial channel.
- Communication with or without echo.
- Status control codes provided for host computer.
- All functions are programmable via serial interface.
- Programmed output voltages are read on analogue outputs; real output voltages on analogue inputs.
- Digital output lines are individually programmable, or in blocks of 8 bits.
- Analogue output voltages are individually programmable.
- Automatic syntax-checker for control commands.

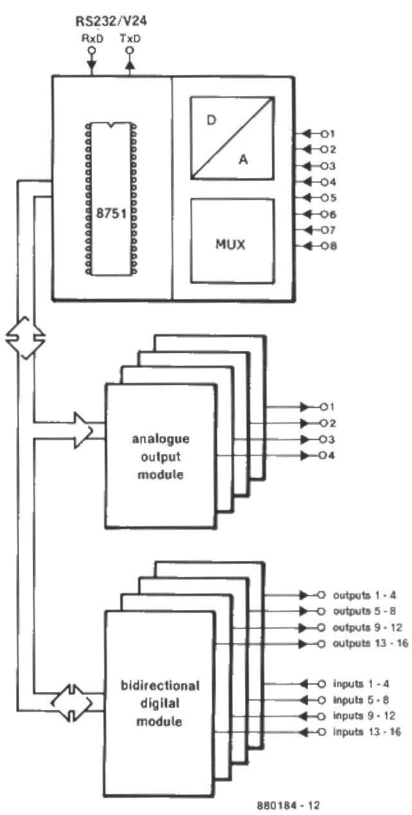


Fig. 2. Modular structure of the autonomous I/O controller.

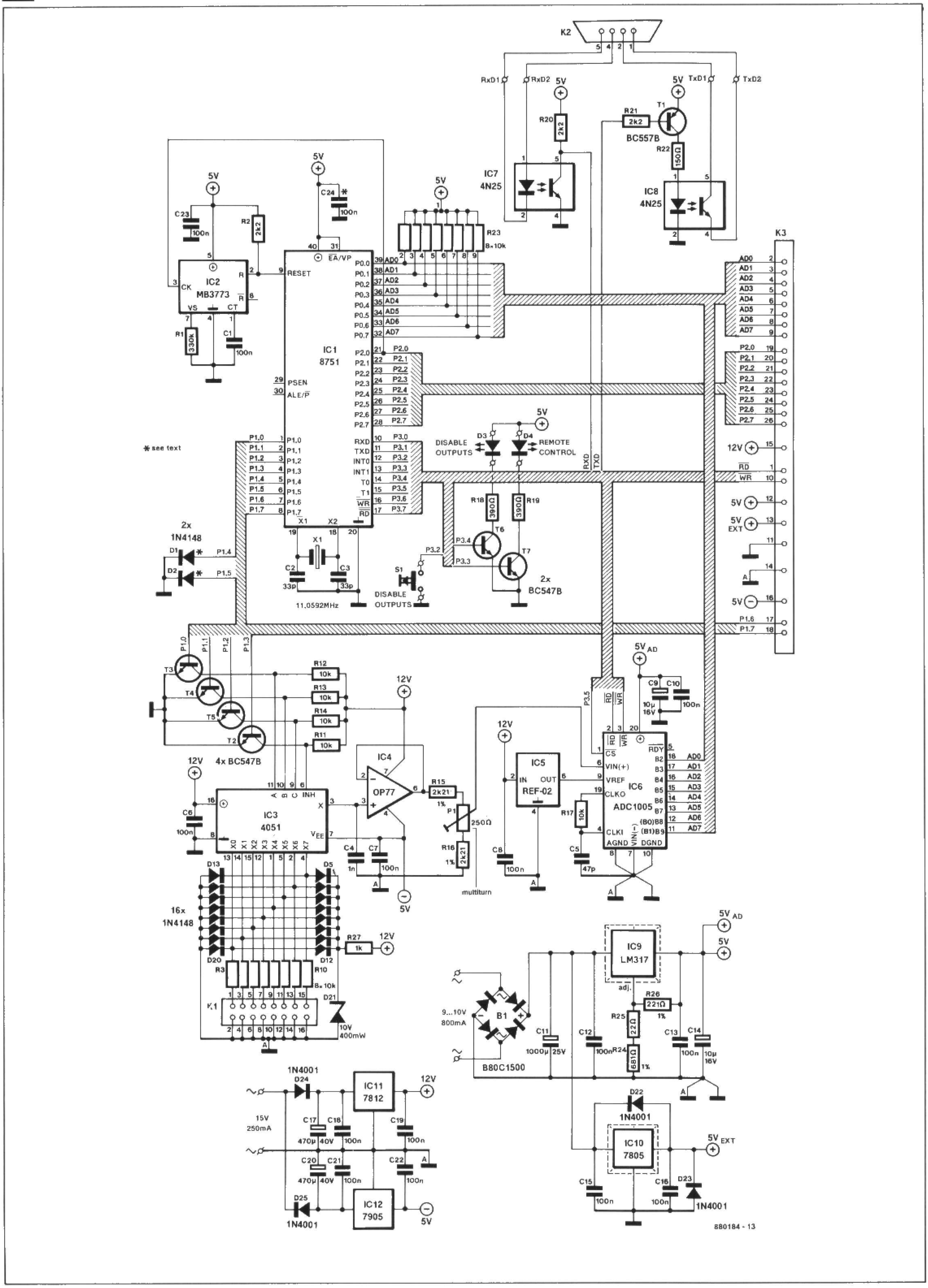


Fig. 3. Circuit diagram of the controller board, which holds the micromicrocontroller, the A-D converter, and a number of peripheral chips.

Analogue-to-digital conversion

The 8 analogue inputs on connector K_1 are connected to protective diode-resistor networks. The CPU, IC_1, controls the ADC direct, and the input multiplexer, IC_3, via 4 level converters, T_2 to T_5. The INH (inhibit) input of the Type 4051 CMOS analogue multiplexer, in combination with capacitor C_4 and opamp IC_4, makes it possible to realize a basic sample-and-hold function. C_4 is dimensioned such that it provides an acceptable compromise between rise and fall time — the conversion error it introduces is less that ½LSB. Potential divider R_{15}-P_1-R_{16} scales the sampled analogue voltage down to a value between 0 and 5 V.

The analogue inputs form a high impedance when they are not sampled. When they are, the impedance drops to about 10 kΩ. The procedure for loading and conversion to 8 bits of the 10-bit data in ADC Type ADC1005 is largely similar to that adopted for the Type DAC1006 (for details, see Ref. 3). An important feature of the ADC1005 is its insensitivity to current peaks during the actual conversion process, as well as to occasional negative voltages supplied by opamp IC_4. No attempt should be made to suppress the current peaks by fitting a capacitor at the input of the ADC, since this would result in significant conversion errors.

Bidirectional digital card and analogue output card

The circuit diagrams of these modules are given in Figs. 4 and 6 respectively. For a description of the operation, refer to Ref. 3 (but note the value of R_2 on the analogue voltage board, and the supply voltages). The address assignment can be deduced from Table 2. The digital I/O cards can only be addressed by fitting jumpers $\overline{E0}$ to $\overline{E3}$ (on K_3), the analogue output boards by fitting jumpers $\overline{E4}$ to $\overline{E7}$ (also on K_3). Do not swap cards of a different type.

Table 2.

K3	Peripheral module
$\overline{E0}$	digital card 0
$\overline{E1}$	digital card 1
$\overline{E2}$	digital card 2
$\overline{E3}$	digital card 3
$\overline{E4}$	analogue card 0
$\overline{E5}$	analogue card 1
$\overline{E6}$	analogue card 2
$\overline{E7}$	analogue card 3

Construction

The printed circuit boards for building the autonomous I/O controller are shown in Figs. 7 (controller board; double-sided, through-plated), 8 (digital I/O board) and 9 (analogue output board). The 26-way flat-ribbon cable

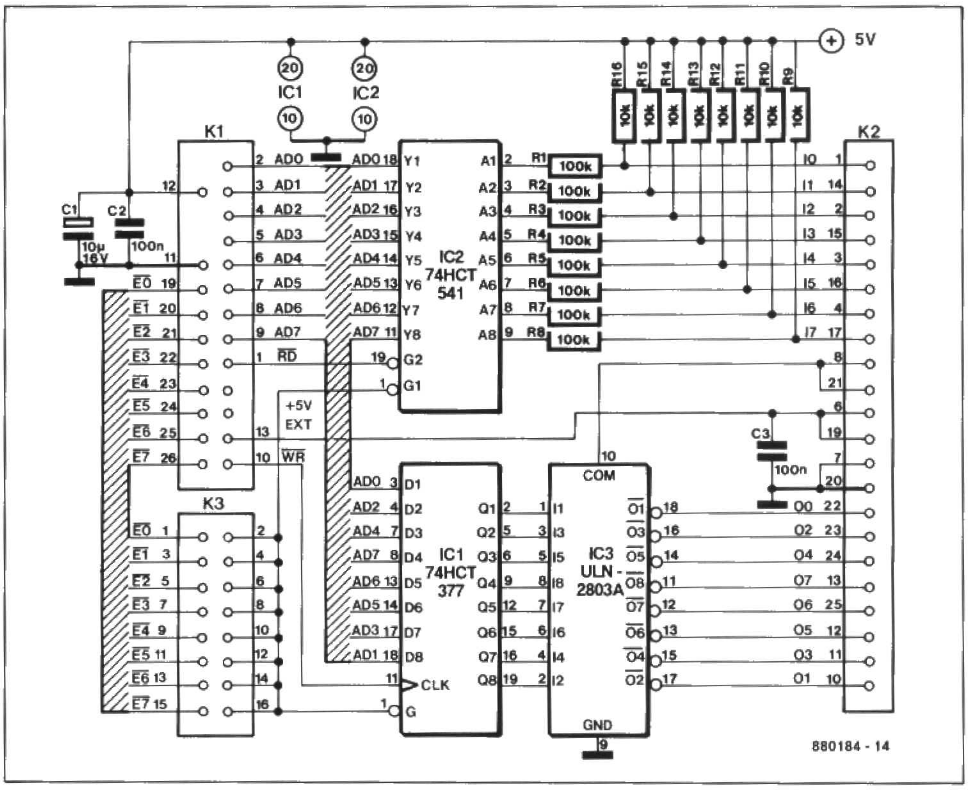


Fig. 4. Circuit diagram of the bidirectional digital I/O card.

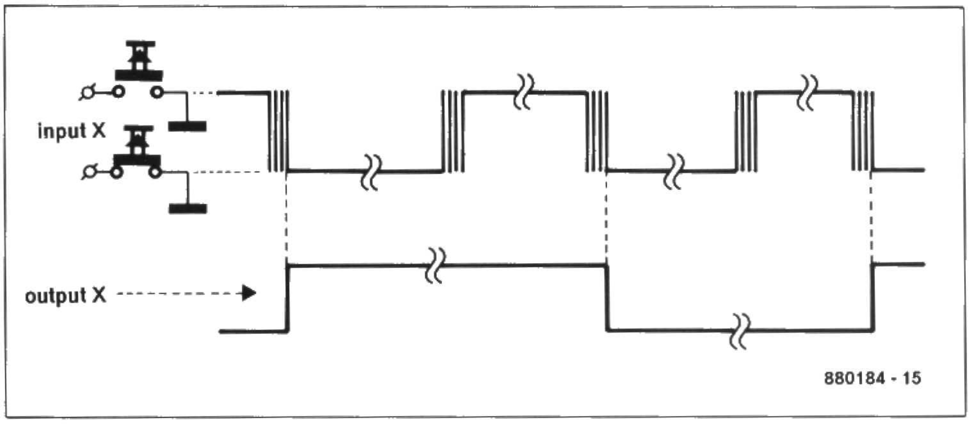


Fig. 5. Key-debounce application of the bidirectional digital card.

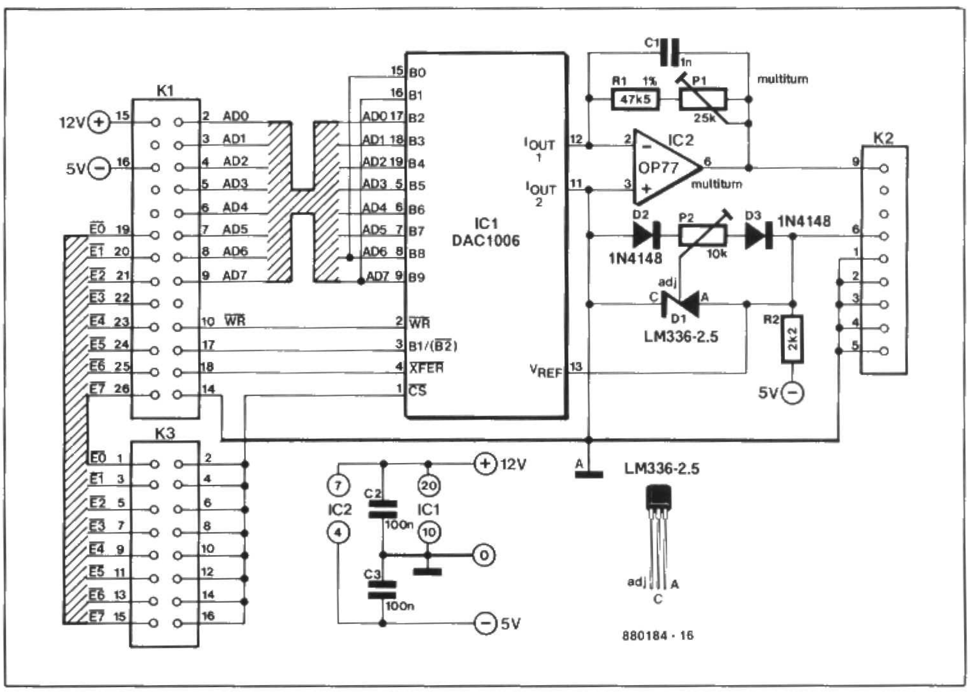


Fig. 6. Circuit diagram of the analogue output card.

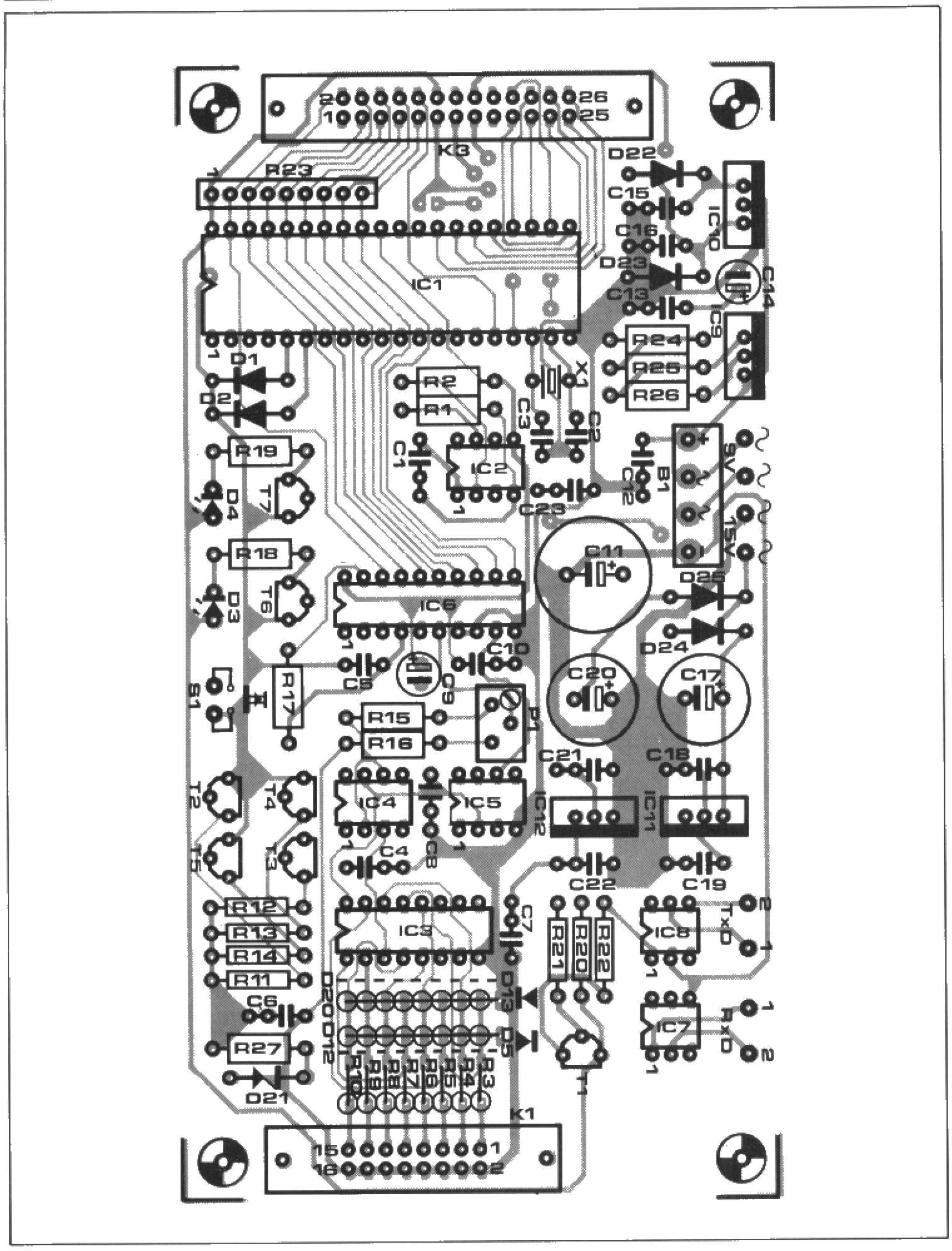


Fig. 7. Component mounting plan of the double-sided, through-plated, controller board of the autonomous I/O controller.

that 'buses' connectors K_1 of the digital and analogue boards connects these to the controller board.

Construction of the controller board should not cause difficulty. Note that all electrolytic capacitors are radial types that are fitted upright. Component R_{23} is an 8-way, 9-pin, single-in-line (SIL) resistor network. Make sure that the protective diodes are fitted the right way around (D_5 to D_{12}: cathode up; D_{13} to D_{20}: cathode down). The 5 V regulators may be fitted on to the cabinet side panel with the aid of insulating washers.

It is recommended to fit supply decoupling capacitor C_{23} at the track side of the board, straight across pins 20 and 40 of the microcontroller.

The photograph in Fig. 11 shows the prototype of the autonomous I/O controller fitted in an enclosure of the same size as that used for the microcontroller-driven power supply. There is plenty of space left for fitting two mains transformers (a single type that provides approximately 9 V at 0.8 A, and 15 V at 250 mA, may be difficult to obtain).

The drawing of Fig. 10 and the ready-made, self-adhesive, front-panel available for this project are used as templates for preparing the aluminium front panel of the enclosure. Remember to drill recessed holes for the countersunk screws that secure the D-type sockets and anything else attached to the inside of the front panel, such as horizontal support pillars between this and the rear panel. Small additional holes are drilled in the front panel as shown in Fig. 10 to give access the multiturn presets on the analogue output boards (these holes are not provided in the self-adhesive front panel foil, and must be punched after carefully lining up the completed analogue boards behind the aluminium front panel). A sharp hobby knife is used for clearing the holes for the sub-D connectors in the foil.

Adjustment of the analogue output board is carried out as described in Ref. 3. The board with identification

Parts list

Autonomous I/O controller:
Controller board

Resistors (±5%):
R_1 = 330K
R_2;R_{20};R_{21} = 2K2
R_3 . . . R_{14} incl.;R_{17} = 10K
R_{15};R_{16} = 2K21; 1%
R_{18};R_{19} = 390R
R_{22} = 150R
R_{23} = 10K; 8-way SIL resistor network
R_{24} = 681R; 1%
R_{25} = 22R
R_{26} = 221R; 1%
R_{27} = 1K0
P_1 = 250R multiturn preset (Bourns series 3266; top adjustment)

Capacitors:
C_1;C_6;C_7;C_8;C_{12};C_{13};C_{15};C_{16};C_{18};C_{19};C_{21};C_{22} = 100n
C_2;C_3 = 33p
C_4 = 1n0
C_5 = 47p
C_9;C_{14} = 10µ; 16 V; radial
C_{10} = 100n ceramic
C_{11} = 1000µ; 25 V; radial
C_{17};C_{20} = 470µ; 40 V; radial

Semiconductors:
B_1 = B80C1500
D_1;D_2;D_5 . . . D_{20} incl. = 1N4148
D_3;D_4 = LED
D_{21} = zener diode 10 V; 0.4 W
D_{22} . . . D_{25} incl. = 1N4001
T_1 = BC557
T_2 . . . T_7 incl. = BC547
IC_1 = 8751. Available ready-programmed as order number ESS704 (see Readers Services page; this device is copy-protected).
IC_2 = MB3773 (Fujitsu)
IC_3 = 4051
IC_4 = OP-77 (PMI)
IC_5 = REF-02 (PMI)
IC_6 = ADC1005 (National Semiconductor)
IC_7;IC_8 = 4N25
IC_9 = LM317
IC_{10} = 7805
IC_{11} = 7812
IC_{12} = 7905

Miscellaneous:
K_1 = 16-way angled PCB header with eject handles.
K_2 = 9-way male sub-D connector (not on PCB).
K_3 = 26-way angled PCB header with eject handles.
S_1 = miniature push-button.
X_1 = quartz crystal 11.0592 MHz (C-I Electronics).
PCB Type 880184 (see Readers Services page).

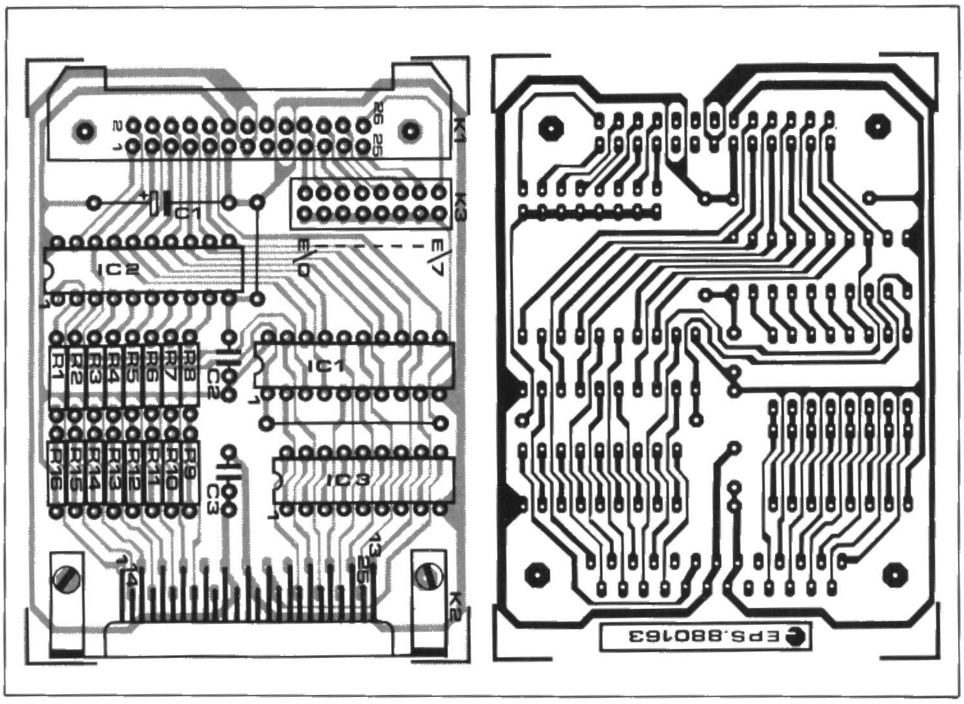


Fig. 8. Printed circuit board for the digital I/O board.

Parts list
Autonomous I/O controller:
digital I/O board

Resistors:
R1 . . . R8 incl. = 100K
R9 . . . R16 incl. = 10K

Capacitors:
C1 = 10µ; 16 V
C2;C3 = 100n

Semiconductors:
IC1 = 74HCT377
IC2 = 74HCT541
IC3 = ULN2803A

Miscellaneous:
K1 = double-row 26-way right-angled header, or 26-way right-angled male header with eject handles.
K2 = 25-way D connector, male, with right-angled pins.
K3 = double-row 16-way straight PCB header.
1 jumper for mounting on K3.
PCB Type 880163 (see Readers Services page).

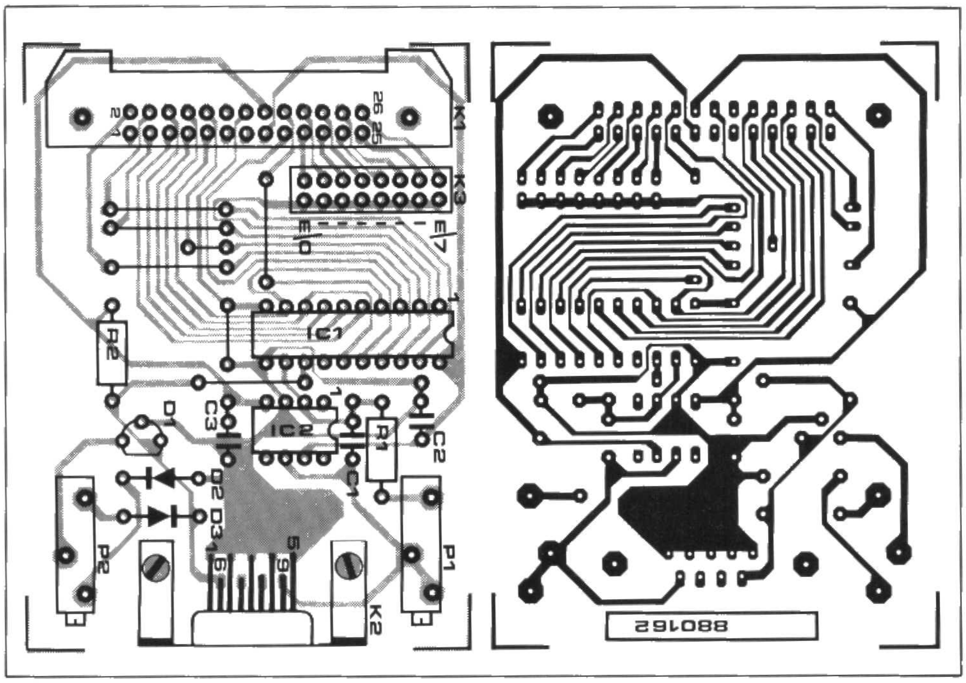


Fig. 9. Printed circuit board for the analogue output board.

Parts list
Autonomous I/O controller:
analogue output board

Resistors:
R1 = 47K5 1%
R2 = 2K2
P1 = 25K or 22K multiturn preset
P2 = 10K multiturn preset

Capacitors:
C1 = 1n0
C2;C3 = 100n

Semiconductors:
D1 = LM336-2V5
D2;D3 = 1N4148
IC1 = DAC1006 (National Semiconductor)
IC2 = OP-77 (PMI)

Miscellaneous:
K1 = double-row 26-way right-angled header, or 26-way right-angled male header with eject handles.
K2 = 9-way D connector, male, with right-angled pins.
K3 = double-row 16-way straight PCB header.
1 jumper for mounting on K3.
PCB Type 880162 (see Readers Services page).

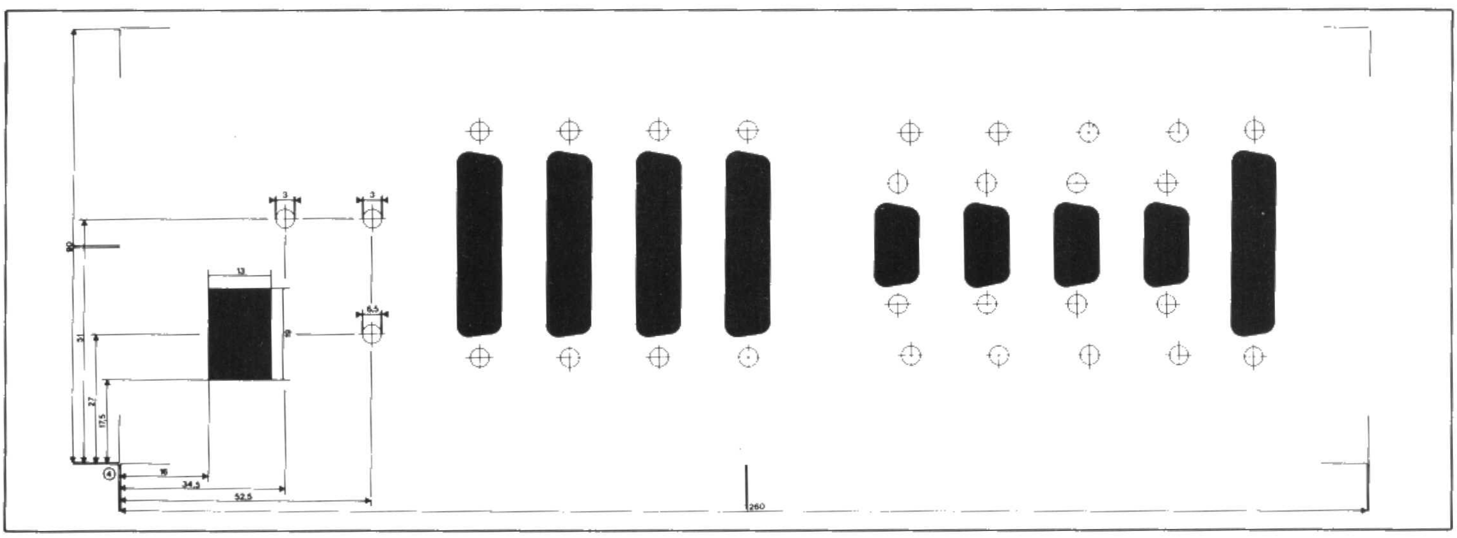


Fig. 10. Front panel drilling template.

number n is programmed to provide 10.00 V with the aid of instruction

Un,10.00.

The ADC on the controller board is calibrated by applying a precision voltage of 10.00 V and adjusting P_1 until the host computer reads exactly this value. Details on programming the autonomous I/O controller will be given in next month's final instalment.

Finally, note that the logic ground and the analogue ground are interconnected at one point only, close to the ADC1005.

References:

1. Microcontroller-driven power supply. *Elektor Electronics* May 1988, June 1988, September 1988.
2. BASIC computer. *Elektor Electronics* November 1987.
3. Peripheral modules for BASIC computer. *Elektor Electronics* October 1988.
4. Single-chip microcontrollers. *Elektor Electronics* September 1987.

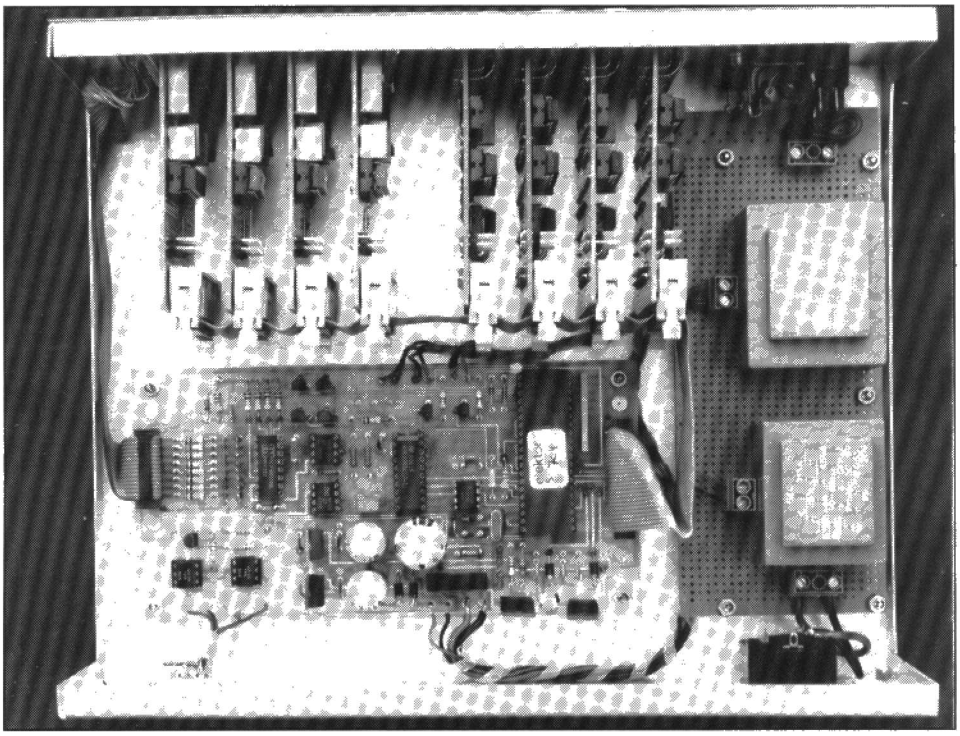


Fig. 11. Internal view of the prototype.

NEWS

SERT AND IEEIE PLAN MERGER

Following discussions between the Society of Electronic and Radio Technicians (SERT) and the Institution of Electrical and Electronics Incorporated Engineers (IEEIE), a Report of the Joint Amalgamation Committee has been prepared and the councils of the two bodies are holding meetings with their members to discuss a merger.

Copies of the report have been sent to all members of SERT and IEEIE, and each body is arranging a series of meetings around the country so that its members can attend and raise questions on any points arising from the report.

AFDEC STATISTICS REVEAL RECORD BILLINGS FOR JUNE

The latest AFDEC (Association of Franchised Distributors of Electronic Components) figures, covering the electronic distribution sector for the 2nd quarter of 1988, show that billings for June were the highest in AFDEC's history.

Against this, the book:bill ratio has fallen to a low for the year, which is caused by the very high sales figures rather than a poor order intake.

The next six months are not expected to be as good either in absolute terms or in terms of relative buoyancy.

RACAL RADIOS SHARE IN EVEREST SUCCESS

Lightweight radio equipment supplied by Racal-Tacticom provided a vital communications link that helped a British expedition on Mount Everest to overcome one of the last great challenges in mountaineering.

The two members of the team who became the first men ever to traverse successfully the treacherous pinnacles of the north-east ridge of Everest carried two of Racal's small hand-portable radios to keep in direct contact with the base camp some 3660 metres below, despite bad weather, hostile both to men and electronics.

The radios carried by the climbers were PRM4720s, compact VHF transceivers operating in the 30-88 MHz band. At the advance camp, a 50 W HF manpack radio Type BCC39 provided a link with a similar set at the base camp. In addition to this, the base camp was also equipped with a UK/PRC351 transceiver, which is part of the Clansman family of radios used by the British Army.

LONG-TERM COMMUNICATIONS JOINT VENTURE

A joint venture agreement worth an estimated £120 million has been signed in Peking by GEC-Plessey Telecommunications—GPT.

The 15-year agreement includes the manufacture, sales and distribution of the company's ISDX (integrated services digital exchange) business communications system. It will involve a phased transfer of technology from the United Kingdom to Shanghai, where production will reach 100,000 lines per year. The ISDX was launched in 1983 and quickly became the leading product in the liberalized UK market. Nearly 1.5 million lines of ISDX have been sold world-wide.

UK SECTION OF FIRST TRANSATLANTIC OPTIC CABLE COMPLETED

The British Telecom cable ship CS *Alert* has successfully completed laying the 500 km long UK section of TAT-8, the world's first transatlantic optical fibre cable.

The UK section of the cable runs from Widemouth Bay in Cornwall to a special junction device on the floor of the Atlantic Ocean. This device will link it to a similar section from France, after which both sections will be connected to the main 6,000 km span of the cable to the US.

When TAT-8 comes into operation during 1989, it will carry the equivalent of 40,000 simultaneous transatlantic telephone calls or the equivalent in data, telex, facsimile, graphics, or television pictures.

CUMULATIVE INDEX 1988

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Computers and microprocessors

Components, design ideas and application notes

General interest

Informative articles

Radio, television and video

Test and measurement

Corrections and updates

S = *supplement page number*

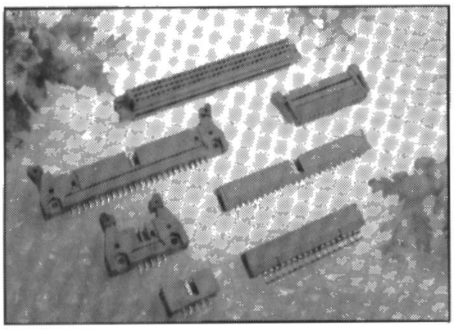
BB-39

NEW PRODUCTS

Video display driver

MCP now have available the Teledyne Philbrick TP 1900, a high performance variable gain amplifier that is capable of directly drivig a video display (CRT cathode).

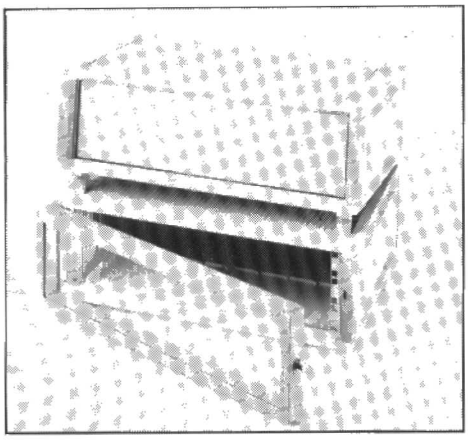
MCP Electronics Ltd • 26-32 Rosemont Road • Alperton • WEMBLEY HA0 4QY.



Pre-wired DIN 41612 connector

The ODU KONTAKT 538 series DIN 41612 c 64-pin connectors, of which pre-wired sets can be supplied, are available from

Electronic Component Marketing Ltd • 62 Military Road • East Sussex TN31 7NY.



New Look for West Hyde's Internorm

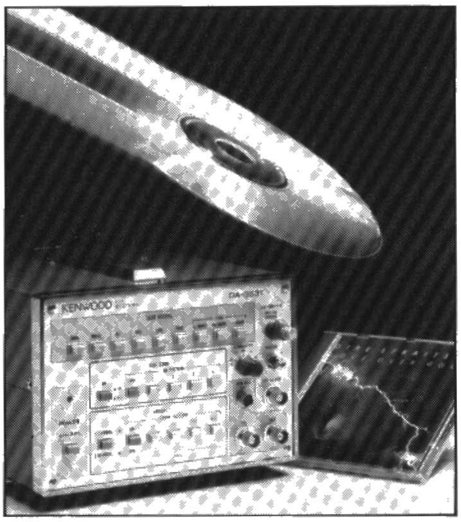
West Hyde's best-selling Internorm case has been given a new look with the addition of an optional door.

West Hyde Developments Ltd • 9-10 Park Industrial Estate • AYLESBURY.

HF silicon MMIC amplifier

Avantek have introduced a new MODAMP cascadable silicon bipolar amplifier that offers very flat gain over a wide bandwidth. The device is a general purpose, 50-ohm gain block intended for use in broad bandwidth IF and RF amplifiers.

Wave Devices • Laser House • 132-140 Goswell Road • LONDON EC1V 7LE. For Avantek distributors outside the UK, see the January 1988 issue of Elektor Electronics.



CD test equipment

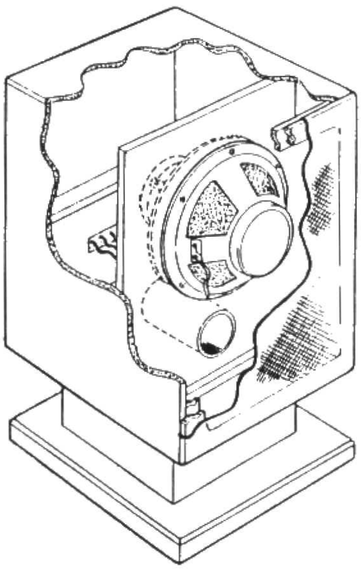
The Kenwood range of compact-disc test equipment is now available from Thurlby Electronics. Built for professional use, the range includes encoders and decoders, jitter analysers and a subcode generator. A CD test disc is also available.

Thurlby Electronics Ltd • New Road • St. Ives • HUNTINGDON PE17 4BG.

Waterproof LED indicators

Bulgin's range of waterproof LED indicators come in a choice of three finishes: matt black, chrome, or satin anodized. They are designed for mounting into an 8 mm diameter panel hole.

A F Bulgin + Company PLC • Bypass Road • BARKING IG11 0AZ.



Subwoofer Kit

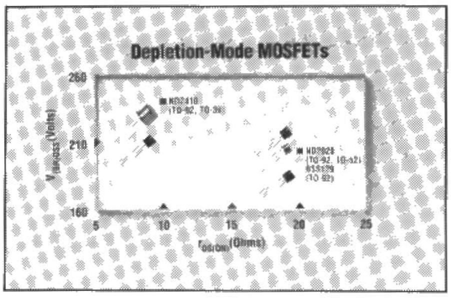
The SUPER PP, a single-cabinet push-pull system using two low-resonance polypropylene-coned 12.5 inch bass units, is the latest addition to Wilmslow Audio's range of DIY subwoofer kits.

Wilmslow Audio Ltd • 35-39 Church Street • Wilmslow • CHESHIRE SK9 1AS.

Networking capabilities

The Highland Distribution Programmable Control Group can provide all relevant hardware and software to meet customers' specific networking requirements. Full technical support is available locally to customers via the Highland national field sales force and regional applications engineers, as well as from the company's headquarters, where regular training courses are held.

Highland Electronics Ltd • Albert Drive • BURGESS HILL RH15 9TN.



New depletion-mode MOSFETs

Siliconix has introduced a family of high-voltage depletion-mode MOS transistors. These new devices have the normally on-switching aspects of a JFET, and the speed and performance characteristics of a MOSFET.

Siliconix Ltd • 3 London Road • NEWBURY RH13 1JL.

Radio test system

Marconi Instruments' Type 2960 radio test system is now available from Instrumentex. The new system combines the Marconi Type 2955 radio communications test set with a single adaptor, allowing it to be used for testing different systems including Band III radio.

Instrumentex • Dorcan House • Meadfield Road • Langley • SLOUGH SL3 8AL.

New OTDR

A new dual wavelength Optical Time Domain Reflectometer designed to evaluate both 1300 nm and 1550 nm single-mode links has been announced by Schlumberger Instruments.

Schlumberger Instruments • Victoria Road • FARNBOROUGH GU14 7PW.

LFA-150: A FAST POWER AMPLIFIER (FINAL PART)

from a basic idea by A. Schmeets

Protection circuit. The protection circuit serves to:

- delay the energizing of the output relay by a few seconds from power-on;
- on switch-on, monitor the d.c. resistance of the loudspeaker: if this is lower than 2.2 ohms, the output relay is not energized;
- deactuate the output relay if the direct voltage across the output terminals of the amplifier rises above 1 volt;
- deactuate the output relay if the peak current flowing in the output transistors rises above 10 A;
- deactuate the output relay if one, or both, of the secondary a.c. voltages fails—this also ensures that the loudspeakers are disconnected from the output when the amplifier is switched off.

The circuit diagram of the protection unit is shown in Fig. 9. Note, however, that the output relay and the peak-current detector are located on the current-amplifier board.

The 24-V output relay is actuated by T_{41} and T_{43}. These transistors form a Schmitt trigger, so that the relay is actuated when the potential across C_{47} has risen to about 12 V and is de-energized when that voltage has dropped to about 6 V. The hysteresis is determined by R_{99} and R_{100}.

Inverter T_{42} in the collector circuit of T_{41} conducts when the protection circuit is on, and this causes D_{29} to light.

When the power is switched on, C_{47} charges via R_{97}. Once the potential across the capacitor has reached a value of about 12 V, T_{43} begins to conduct. Transistor T_{43} is then switched on and the output relay is energized.

Capacitor C_{47} is shunted by transistor T_{40}, which enables it to discharge very rapidly if a fault arises. The base circuit of the transistor is connected to a poten-

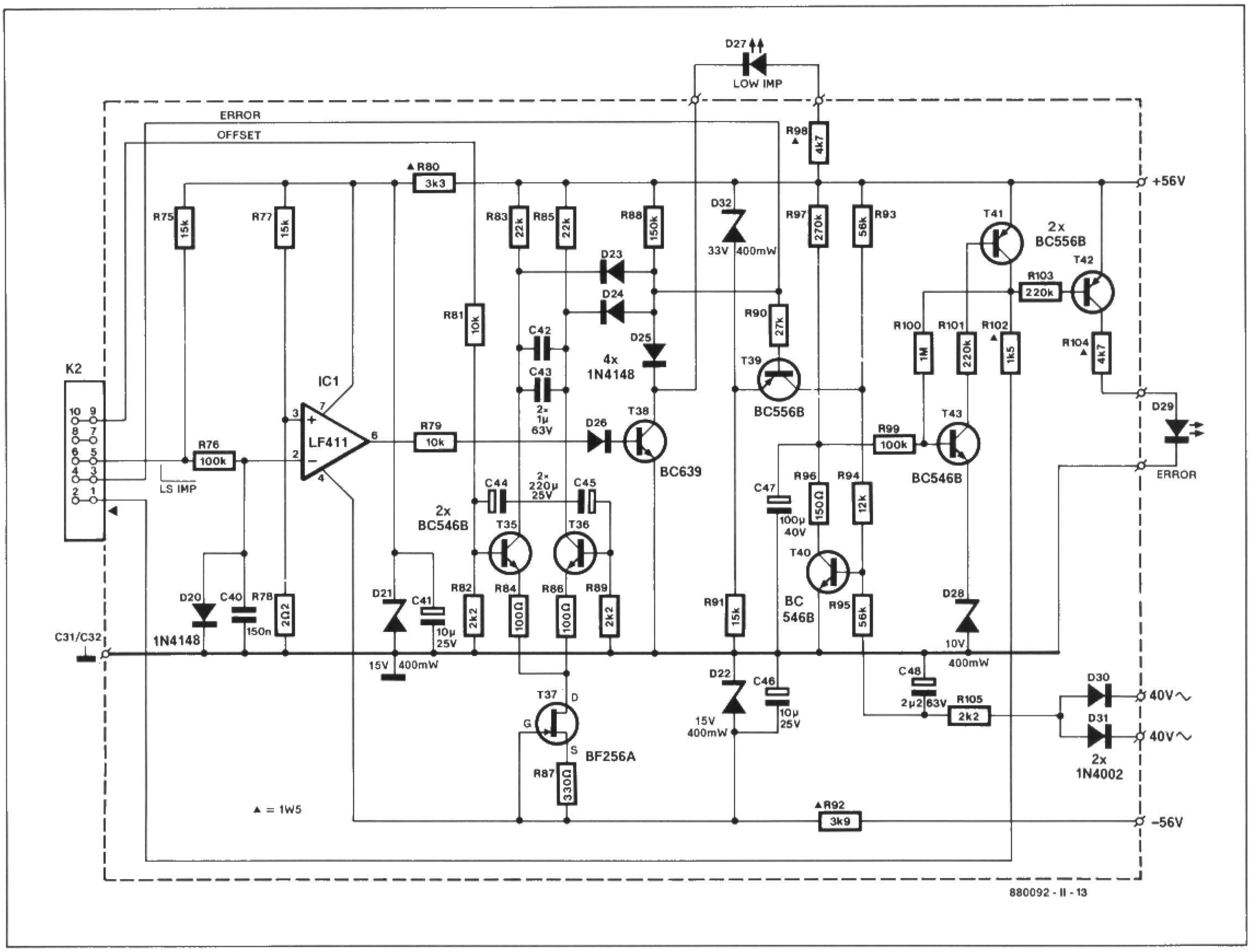


Fig. 9. Circuit diagram of the protection unit.

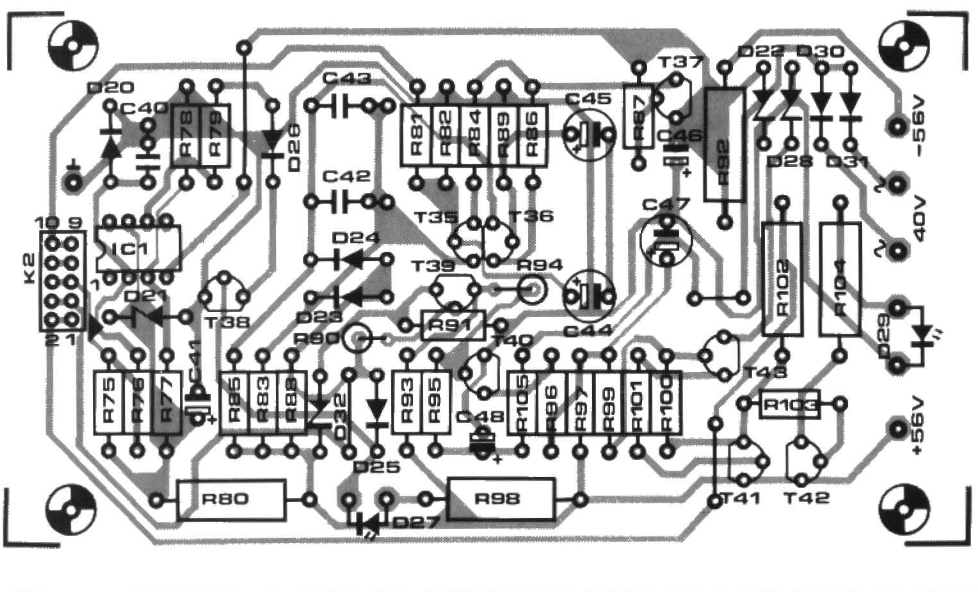


Fig. 10. Printed-circuit board for the protection unit.

Parts list

PROTECTION BOARD

Resistors (±5%):
R_{75};R_{77};R_{91} = 15K
R_{76};R_{99} = 100K
R_{78} = 2R2
R_{79};R_{81} = 10K
R_{80} = 3K3; 1.5 W
R_{82};R_{89};R_{105} = 2K2
R_{83};R_{85} = 22K
R_{84};R_{86} = 100R
R_{87} = 330R
R_{88} = 150K
R_{90} = 27K
R_{92} = 3K9; 1.5 W
R_{93};R_{95} = 56K
R_{94} = 12K
R_{96} = 150R
R_{97} = 270K
R_{98};R_{104} = 4K7; 1.5 W
R_{100} = 1M0
R_{102} = 1K5; 1.5 W
R_{101};R_{103} = 120K

Capacitors:
C_{40} = 150n
C_{41};C_{46} = 10μ; 25 V
C_{42};C_{43} = 1μ0; 63 V
C_{44};C_{45} = 220μ; 25 V
C_{47} = 100μ; 40 V
C_{48} = 2μ2; 63 V

Semiconductors:
D_{20};D_{23} . . . D_{26} incl. = 1N4148
D_{21};D_{22} = 15 V; 0.4 W zener diode
D_{27} = yellow or orange LED
D_{28} = 10 V; 0.4 W zener diode
D_{29} = red LED
D_{30};D_{31} = 1N4002
D_{32} = 33 V; 0.4 W zener diode
T_{35};T_{36};T_{40};T_{43} = BC546B
T_{37} = BF256A
T_{38} = BC639
T_{39};T_{41};T_{42} = BC556B
IC_1 = LF411CN

Miscellaneous:
K_2 = 10-way header for PCB mounting.
Two IDC sockets to mate with K_1 and K_2.
PCB Type 880092-3 (see Readers Services page).

tial divider, R_{93}-R_{94}-R_{95}, which is dimensioned to ensure that the output relay is deactuated as soon as one, or both, of the secondary a.c. voltages fails. The junction R_{95}-R_{105}-C_{48}- is at a negative d.c. potential that is derived from the secondaries of mains transformer Tr_2.

Junction R_{93}-R_{94} is connected to the base of T_{39}, which with D_{32} and R_{91} forms a sort of comparator. Several of the protective measures are controlled via this transistor. When the base potential of the transistor drops below around 23 V (56 V minus the 33-V drop across D_{32}), T_{40} begins to conduct and the output relay is de-energized.

The value of the d.c. resistance of the loudspeaker is monitored by IC_1. The inputs of the circuit are connected to a Wheatstone bridge, one arm of which consists of R_{75} and the loudspeaker resistance, and the other of R_{77} and R_{78}. Measurements can, of course, only be effected when the output relay is not actuated, because only then is the voice coil connected to pins 5 and 6 of connector K_2 via the relay contacts. Since the d.c. resistance is determined from direct voltages of only a few millivolts, network R_{76}-C_{40} has been incorporated to prevent error signals arising from ambient noise. Diode D_{20} limits the potential across C_{40}.

If the d.c. resistance of the loudspeaker drops below the value of R_{78} (2.2 Ω), IC_1 toggles which causes T_{38} to conduct. Diode D_{27} then lights to indicate that the loudspeaker resistance is too low. At the same time, the base voltage of T_{39} is reduced to almost zero via D_{25}: the relay can then not be energized.

When the loudspeaker resistance is higher than 2.2 Ω, the relay is energized a few seconds after power on. The voice coil is then no longer connected to pins 5 and 6 of K2 and IC_1 can not monitor its d.c. resistance. A fresh check on the loudspeaker resistance can only be made when the amplifier is switched on again or another malfunction has caused the relay to be deactuated.

The power supply for IC_1 is derived from the ±56-V lines via zener diodes D_{21} and D_{22} and series resistors R_{80} and R_{92}.

The direct voltage at the output of the amplifier is measured by the differential amplifier formed by T_{35} and T_{36}. The output signal is fed to T_{35} via potential divider R_{81}-R_{82}, and to T_{36} via a bipolar electrolytic capacitor formed by C_{44} and C_{45}. The difference signal across the collectors of the transistors is applied to low-pass section R_{83}-R_{85}-C_{42}-C_{43}. If the d.c. voltage is greater than ±1 V, the collector voltage of either T_{35} or T_{36} drops to such an extent that T_{39} is switched on via D_{23} or D_{24} and this causes the relay to be de-energized via T_{41}. The d.c. operating point of the difference amplifier is set with the aid of constant-current source T_{37}. The current is about 2.5 mA.

Transistors T_{27} and T_{30} in the current amplifier measure the peak voltage across the emitter resistor of one of the output transistors in the positive and negative half of the output signal respectively. The voltage dividers in the base circuit of T_{27} and T_{30} are dimensioned to cause the transistors to conduct when a peak current of 5 A flows through the output transistor. In that case, T_{27} switches on T_{28}, or T_{30} switches on T_{29}: in either event, T_{39} is switched on (via D_{11} or D_{12}) and de-energizes the output relay, so that the loudspeaker is disconnected.

Power for the protection circuit is taken direct from the ±56 V lines, but power supply monitoring diodes D_{30} and D_{31} are connected to the secondary winding of Tr_2 (40 V a.c.).

All other connections between the protection circuit and the amplifier are made via connector K_2.

The PCB for the protection circuit is shown in Fig. 10. Populating this is not likely to present any problems.

Ancillary PSU board. This board, shown in Fig. 11, is intended to house the auxiliary transformer, Tr_1, rectifiers D_{35}—D_{38}, and smoothing capacitors C_{54} and C_{55}. The board is designed to be fitted with a number of terminal blocks to facilitate the inter-wiring of the amplifier sections. Make sure that the smoothing capacitors are rated at 100 V.

Construction

The construction details are given for a mono amplifier: two are, of course, needed for a stereo amplifier.

The heat sink must be at least 170×80 mm and be drilled in accordance with Fig. 8. Its resistance must be not greater than 0.5 K/W. The holes are made with a 2.5 mm drill and then tapped to receive 3 mm machine screws.

The enclosure used for the prototypes measures 245×120×300 mm; for a stereo amplifier, a larger enclosure is needed. A small section must be cut from its rear panel to make space for the heat sink (see Fig. 1). The heat sink is mounted at a height that allows fitting the AF input sockets underneath it. The mains input and loudspeaker terminals are located beside it.

Mains transformer Tr_2, rectifier B_1, and the ancillary PSU board are mounted on the base panel of the enclosure. The board for the protection circuit may be mounted on top of the voltage amplifier as shown in Fig. 7 or, alternatively, at another convenient place in the case.

The mains on-off switch and the POWER, ERROR and LOW IMPEDANCE diodes are mounted on the front panel.

All components in the current amplifier, except T_{20} to T_{26} incl., are fitted at the **track side** of the board a few millimetres above the surface.

Inductor L_1 consists of 12 turns 1.5 mm thick enamelled copper wire on a hollow former of roughly 15 mm diameter. Resistor R_{63} is inserted into the centre of the former and the whole assembly is fitted on the board in one go, again a few millimetres above the surface.

Seven solder pins and a 10-way connector are used for the remaining connections with the other sections of the amplifier.

The terminals of T_{20}, T_{21}, and T_{22} are bent upwards 90° about 3 mm from their housing. The transistors are then screwed to the heat sink with the aid of insulating washers with the terminals upwards. It should then be possible to fit the current amplifier board on four 10-mm spacers with the transistor terminals protruding through the appropriate holes in the board (see Fig. 5).

Next, the terminals of the output transistors are bent as shown in Fig. 13. These four transistors are then fitted on to the heat sink with the aid of insulating washers and discs, and plenty of heat conducting paste. Take care that the correct washers and discs are used, because the transistors have different cases. The terminals should coincide with the appropriate solder areas on the board.

All transistor terminals may now be soldered to the board.

Transistor pairs T_3-T4; T_6-T_7; T_8-T_9; and T_{10}-T_{11} should preferably be matched. If that is not feasible, they should come from the same production batch (normally indicated on their body).

Pairs T_3-T_4 and T_6-T_7 are mounted on the board with their smooth sides adjoining. Some heat conducting paste should be applied between each pair, after which the pairs should be tightened together with a nylon cable tie. This is done to ensure that the two transistors in each pair have the same temperature and so prevent their d.c. operating from shifting.

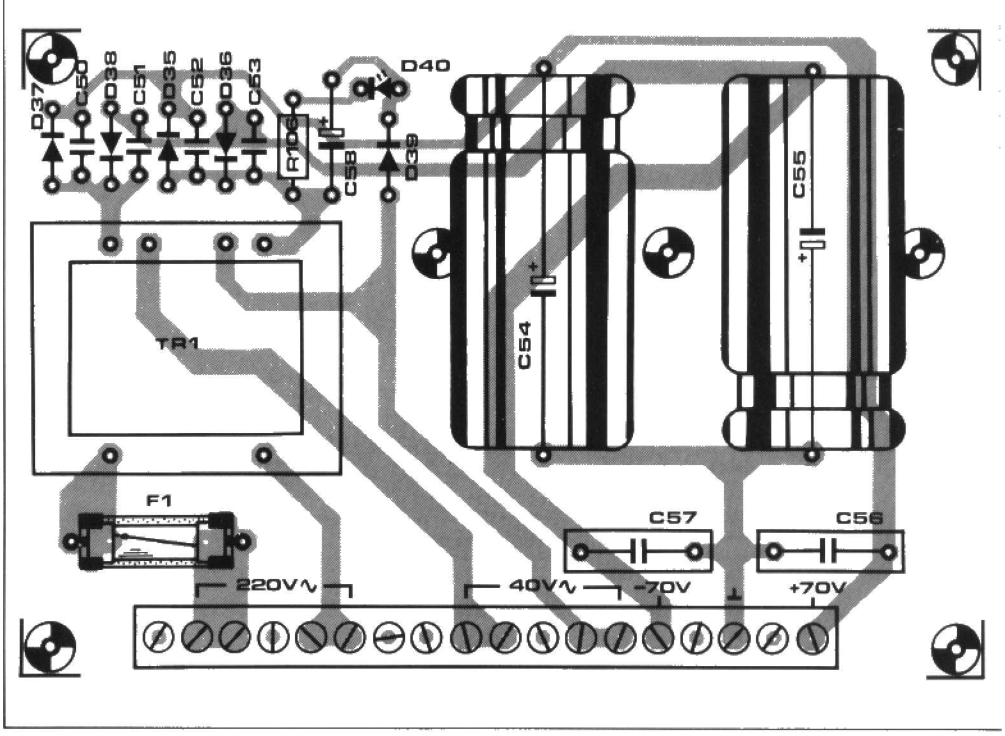


Fig. 11. Printed-circuit board for the ancillary power supply.

The other two pairs are mounted on an L-shaped piece of aluminium, after which the whole assembly (see Fig. 14) is fitted on to the board with the aid of two short spacers. Insulating washers and heat conducting paste should be used in the construction. Solder pins for connections A, B, C, and FB should be fitted at the track side.

When the board is populated, it may be mounted on top of the current amplifier board with the aid of four 35–40 mm spacers.

The mains input plug should preferably be of the type with built-in fuse. From there, a length of mains cable goes to the on-off switch on the front panel. Another length of mains cable goes from the on-off switch to the ancillary PSU board and Tr_2.

Make sure that mains-carrying cables and parts are at correct isolating distance from other parts.

The power supply section is wired in accordance with Fig. 12. Note that the secondary (40 V) voltage is applied separately to the ancillary PSU board. The **only** earth point of the enclosure is wired to the central connection of the 20,000 μF electrolytic capacitors.

Check whether the two mains transformers are connected in series by switching on the mains and verifying that the voltage at the ±70-V terminals is about 70 V with respect to earth. If the voltage is lower, for instance, 45 V, switch off the mains and interchange the two primary connections of Tr_1 on the ancillary PSU board. Again switch on the mains and check the voltage at the ±70-V terminals. When everything is in order, discharge the electrolytic capacitors carefully with the aid of a 470-ohm, 1-watt resistor.

Solder short lengths of (enamelled) cop-

Parts list

ANCILLARY PSU BOARD

Resistor (±5%):
R_{106} = 1K2

Capacitors:
C_{50} . . . C_{53} incl. = 22n
C_{54};C_{55} = 1000μ; 100 V
C_{56};C_{57} = 680n; 100 V
C_{58} = 22μF; 25 V

Semiconductors:
D_{35} . . . D_{39} incl. = 1N4002
D_{40} = green LED

Miscellaneous:
Tr_1 = PCB-mount 3 VA mains transformer 2×9 V; 177 mA.
F_1 = fuse 50 mA (delayed action); with PCB-mount holder.
3 off 6-way PCB terminal block.
PCB Type 880092-4 (see Readers Services page).

Parts list

MAIN POWER SUPPLY
(not on PCB)

B_1 = BYW66
C_{31};C_{32} = 20,000μ; 63 V (or 2×10,000μ)
F_2 = fuse 2.5 A delayed action.
S_1 = double-pole mains switch.
Tr_2 = 300 VA toroid mains transformer 2×40 V; 3.75 A, e.g. ILP Type 73026 (240 V mains) or 71026 (220 V mains). Available from Jaytee Electronic Services.
Mains input socket with built-in fuseholder.
Heat-sink: thermal resistance ≤ 0.55 K/W, e.g. Fischer Type SK47/100-SA (Dau Components).

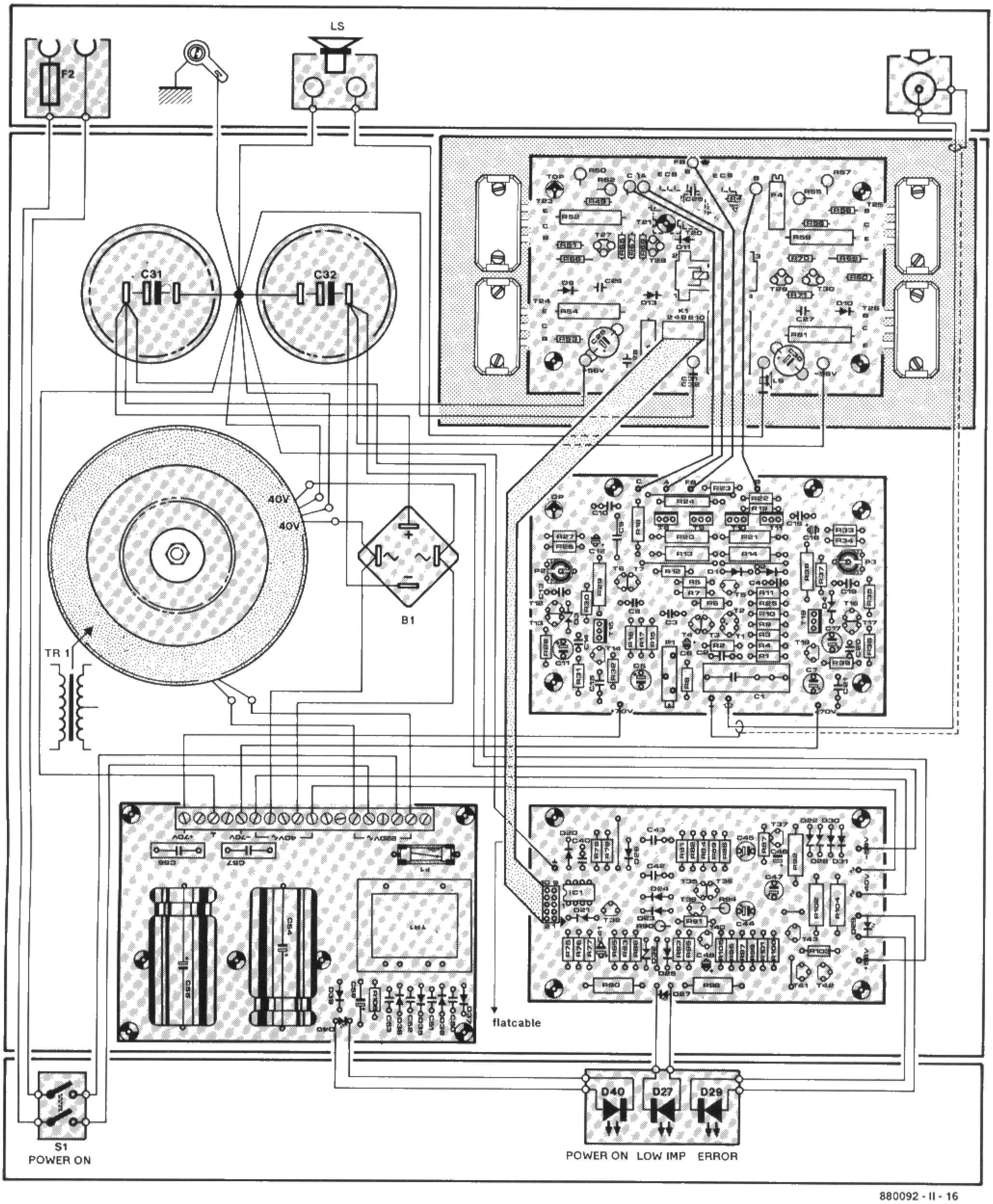


Fig. 12. Inter-wiring diagram for the various sections of the amplifier.

per wire between points A, B, C, and FB on the voltage amplifier and current amplifier boards.
Connect the input socket to the input of the voltage amplifier by a short length of screened cable.
Connect the power input terminals on the current amplifier board to the take-off points on the electrolytic capacitors by 2 mm thick insulated copper wire. Use similar wire for the connections to the output terminals.
The supply terminals on the voltage amplifier board are connected to the 70-V terminals on the ancillary PSU board. The protection board is connected to the current amplifier board via a length of 10-way flatcable terminated at both ends into a suitable 10-way connector. Make sure that pin 1 of the protection board is connected to pin 1 of the current amplifier board.

Setting up

Set P_1, P_2, and P_3 to the centre of their travels, and P_4 to maximum resistance. Switch on the mains supply. After a few seconds, the direct voltages at C_{31+} and C_{32-} should be ±58 V w.r.t. earth.
Adjust P_2 and P_3 to obtain voltages of ±60 V across R_{29} and R_{38} respectively.
Adjust P_1 to obtain a direct voltage of exactly 0 V at the junction $L_1 - R_{63} - re_1$.
Adjust P_4 to obtain a voltage of 20 mV across R_{52} and across R_{54}. This voltage indicates a current of around 90 mA through each output transistor, which ensures trouble-free Class A operation.

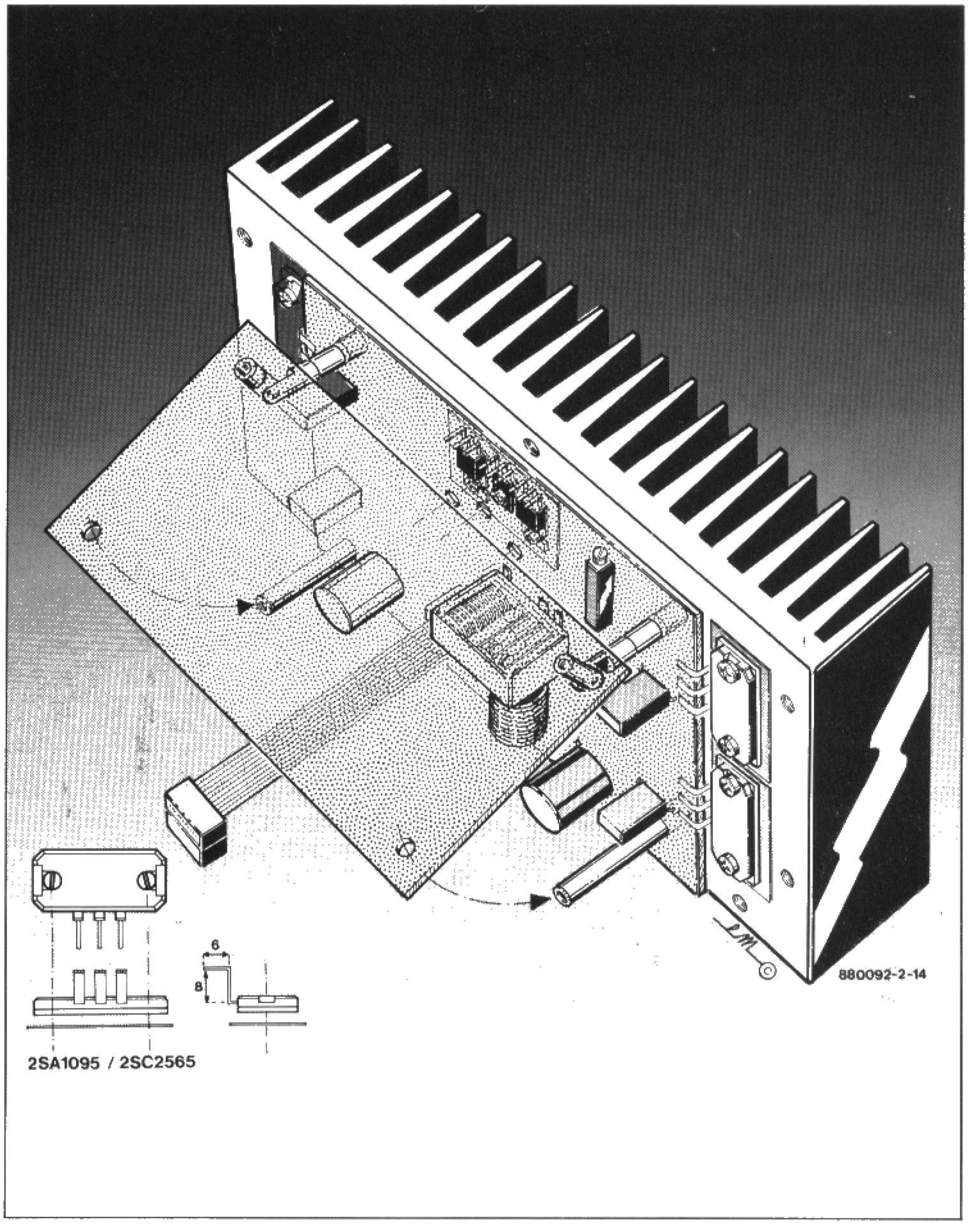


Fig. 13. Mounting of the output and driver transistors on the heat sink.

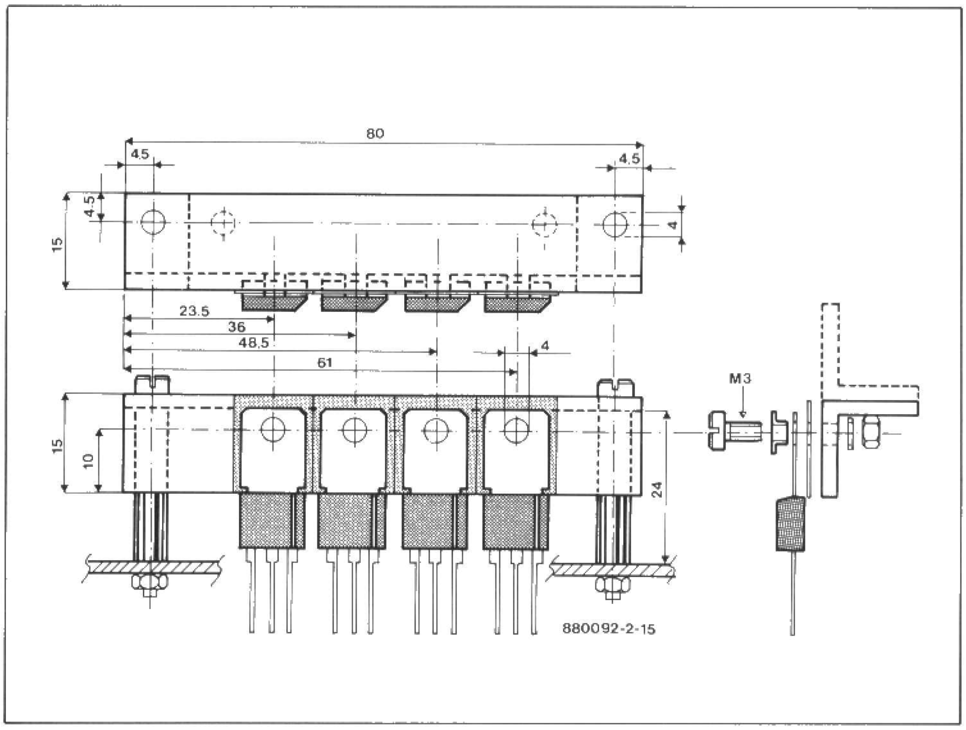
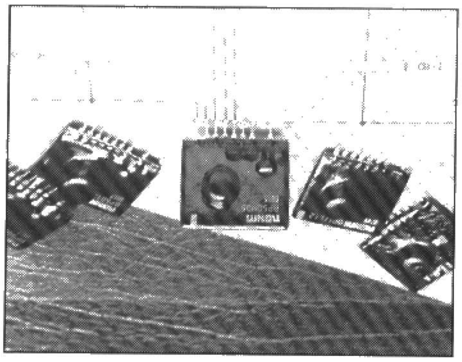


Fig. 14. Construction of the heat sink for $T_8 - T_{11}$.

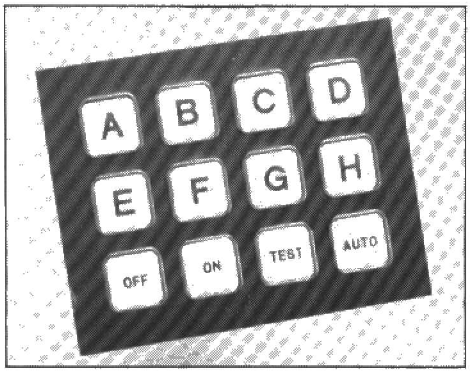
NEW PRODUCTS



8-30 V DC-to-DC converters

ROHM Corporation has announced the BP5000 series of DC-to-DC converters that are intended for use as supplementary on-card voltage regulators. Applications for these devices, which have an input voltage range of 8-30 V, include PCs, telecommunications, PC expansion boards, modems and instrumentation equipment.

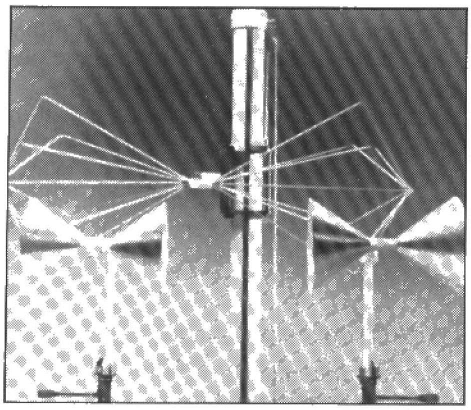
ROHM Corporation • 8 Whatney • IRVINE • CA 92718 • USA.



Low profile keypads

Highland Electronics can now supply the Grayhill Series 89 low-profile keypads. A thin keyboard with facilities for self-legending is also available.

Highland Electronics Ltd • Albert Drive • BURGESS HILL RH15 9TH.



Biconical antenna

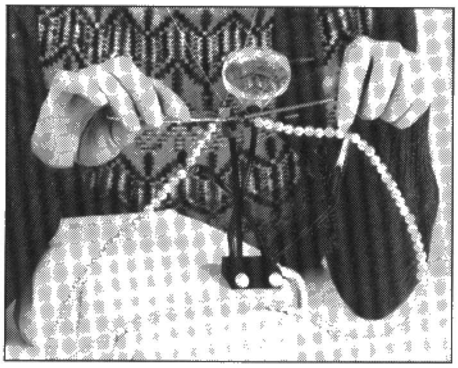
The B-1000 antenna set is a unique and easy-to-use system for measurements from 30 to 1000 MHz. It combines the broadband biconical antenna with an impedance transformer to offer unparalleled accuracy and covenience of use.

Fieldtech Heathrow Ltd • Huntavia House • 420 Bath Road • LONGFORD UB7 0LL.

Fast precision opamp

Raytheon Semiconductor has added the OP-47 to its family of high-performance operational amplifiers. The new device is designed for applications where low noise (both spectral density and burst), wide bandwidth and high slew rate are primary requirements.

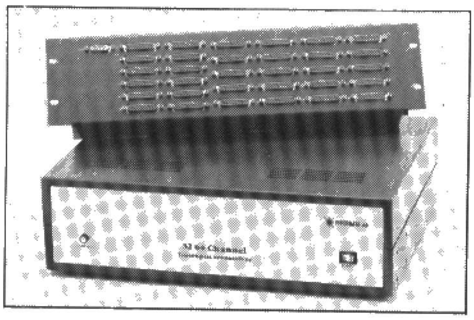
Raytheon Semiconductor • Ogilvie Road • HIGH WYCOMBE HP12 3DS.



Octopus workholder

Freetrade has announced a price cut to just £ 5.95 for the versatile Super Octopus Workholder. This device holds a wide variety of objects at any angle, allowing fine assembly and repair work to be performed with both hands free.

Freetrade (TEP) Ltd • Unit 15 • Avery Industrial Park • Garrison Lane • Bordesley Green • BIRMINGHAM B9 4QE.



32-channel fibre optic transceiver

Fiberdata of Stockholm has designed a fibre optic transceiver with 32 bi-directional channels. Each channel has in turn two bi-directional control signal lines. The transceiver is completely independent of transmission speed and data format.

Tekelec Ltd • Charles House • Toutley Road • BERKSHIRE RG11 5QN.

Golden Max from STC

The Kemet Golden Max ceramic dipped/radial capacitors, ranging in values from 10 pF to 1 μF at 200 V, 100 V, and 50 V, are now available form STC Electronic Services. Encapsulated in a moisture and shock resistant epoxy coating, the capacitors meet the flame requirements of UL 94V-0.

STC ELectronic Services • Edinburgh Way • HARLOW CM20 2DF.

Oryx Portasol Kit

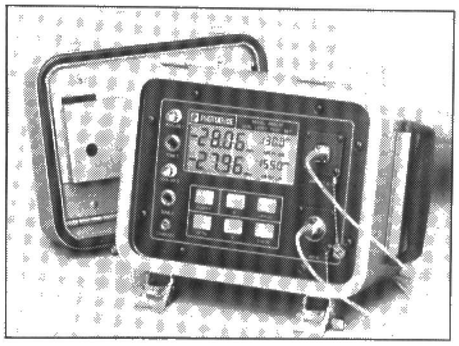
The scope of this kit extends from soldering a semiconductor junction to brazing a domestic boiler. It requires no training and replacement or changing the tip is simplicity itself.

Greenwood Electronics • Portman Road • READING RG13 1NE.

Radio code analyser for Band III

A new version of the 4922 Radio Code Analyser capable of testing mobiles for the Band III Trunked System has been announced by Schlumberger.

Schlumberger Instruments • Victoria Road • FARNBOROUGH GU14 7PW.



Dual-laser fibre optic test set

The Photodyne 2260XF dual-laser test set is designed for use in the installation, maintenance, and trouble-shooting of all fibre optic links operating at the standard wavelengths of 1300 nm and 1550 nm.

Lambda Photometrics Ltd • Lambda House • Batford Mill • HARPENDEN AL5 5BZ.

32-bit RISC microprocessors

Four new microprocessor chip sets based on 32-bit RISC architectures of SPARC and MIPS and offering up to 20 mips of computing power — five times the performance of conventional microprocessors — have been announced by LSI Logic. The new devices will become available in the first quarter of 1989.

LSI Logic Ltd • Grenville Place • The Ring • BRACKNELL RG12 1BP.

Switch fuses

Available from Highland Electronics is the ASEA CONTROL range of SEKF switch fuses. They include DIN, BS, NFC, and NEMA versions.

Highland Electronics Ltd • Albert Drive • BURGESS HILL RH15 9TN.

SCIENCE & TECHNOLOGY

Chip developed for Artificial Intelligence

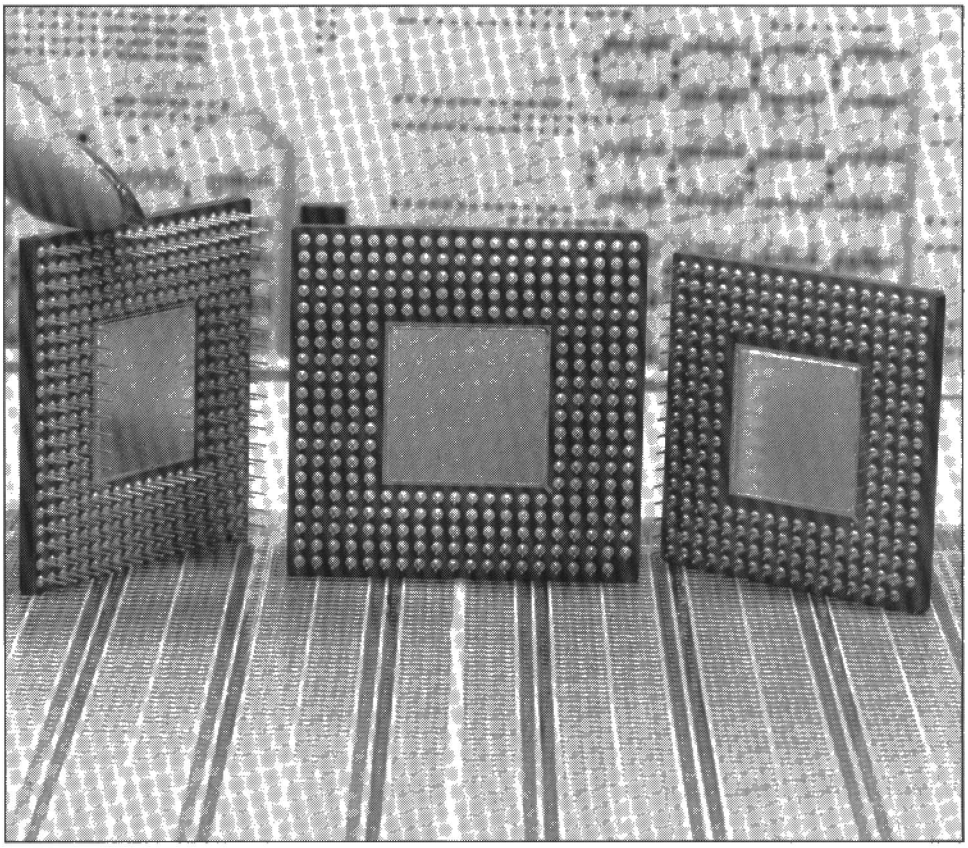
by Leon Clifford

Three chips—an object-oriented memory management unit, a programmable sequencer, and a 40-bit arithmetic an logic unit—are said to be capable of forming the processor for the world's first fifth-generation computer, capable to apply artificial intelligence and to operate hundreds of times faster on many tasks than all but the most expensive mainframe computers.

The circuits have been designed by Linn Smart of Glasgow Computing and are now being developed for use in the popular Sun-3 workstation manufactured by California's Sun Microsystems. The development pitches Linn Smart head-to-head against two United States electronics companies hoping to dominate the AI market: the giant Texas Instruments, which has already fielded an AI board for Apple PCs, and AI specialist, Symbolics, which is also hatching plans to embed its AI chips into PCs and workstations.

Linn Smart makes light of the opposition. They claim that most computers do not understand what they are doing because they know nothing of the structures manipulated by the program. The complexity of modern software systems, with their requirements for the secure manipulation of shared, complex data structures, is beyond their capabilities. They believe that object-oriented languages are the solution and their *Rekursiv* chip set—developed in association with LSI Logic of Livingston—forms the only machine that can support them efficiently.

According to Professor David Harland of Strathclyde University, mastermind behind the *Rekursiv* project, most modern computers have descended from the "beasts" created during the 1940s and are designed to match patterns and break codes.



Tough jobs

This means that although modern computers are ideal for solving arithmetical problems such as bank balances and calculating pay rolls, they are no good at solving real life problems such as stock control, image processing and fault diagnosis. These are tough jobs for conventional computers, specifically designed to do simple number-crunching.

Explained Professor Harland: "You need machines that know what they are trying to do rather than ones that need to be told exactly how to do things. Back in the 1940s they wanted computers for pattern matching and the emphasis was on numerical calculation. But numbers are simple and you only ever want to do a small range of short operations."

Computers evolved that were very well adapted to the job of executing a small set of simple actions on straightforward numbers. Indeed, the current ferment about the so-called reduced instruction set computing (RISC) technology chips is really about taking this process to its logical conclusion and using the smallest possible set of the simplest possible instructions.

RISC chips are very fast at arithmetic, and computers built from them are good at jobs that can be easily turned into mathematics. The computer has to do lots of relatively simple sums involving numbers that represent little more than simple quantities.

The problem that arises is that the world is not made up of numbers: it consists of actual solid objects interrelated in many different ways. And if computers are to solve problems in the real world, they must be designed to cope with these objects.

Young children have no trouble at all in tackling problems that would stump a computer such as stacking toy bricks into piles. Indeed, stacking crates into warehouses or containers on to ships is exactly analogous to toy bricks.

Object oriented

But when it comes to shipping crates out of a warehouse, the fact that there is a television in one and a hi-fi in another is vital. The computer has to deal with more than a simple quantity: it must handle a complete description of the object; everything from what it is and where it is stored to the address of the

purchaser.
In other words, a whole mass of information or data is needed to describe each crate or object precisely enough so that it can be handled correctly. Computers able to cope with this type of problem are called object-oriented computers. This is because they manipulate large amounts of data that describe particular objects or relations between objects as single entities.
This data is encoded in the form of binary numbers up to 40 bits long in the Rekursiv computer board. But these binary numbers encode abstract descriptions of objects and are not just simple quantities. And because of this, these large binary numbers or data objects must be manipulated in special ways by instructions far more complicated than the simple adds and multiplies used in conventional computers.
Linn Smart engineer Duncan McIntyre can see many applications for Linn's technolog. "An obvious one is in large databases where we can deal with data far more effectively and efficiently and in a way that is much more manageable than with conventional systems," he said.
"In the financial community, the persistence of data this system offers makes it useful for trading. It is also useful for design engineers who would benefit greatly from the object-oriented nature of the machine because they could define any part of their design as a single object and manipulate it as a whole."

Fast memory

This may be one reason why Linn Smart is making its first products for the Sun-3 workstation which is now finding its way into City of London dealing rooms as well as development laboratories. The *Rekursiv* chip set has been mounted on to a triple height super extended Eurocard—ideally suited to the VME-bus slots in the Sun-3 chassis.
The board carries 40 Mbits of DRAM memory—enough to store some 40 million different objects—as well as some fast SRAM memory that contains a kind of directory helping to locate the exact position of particular data objects within the computer's memory.
The *Rekursiv* computer chip set has been under development for several years and is now about to be launched on to the market.
The chips at the heart of the *Rekursiv* are manufactured in 1.5 μ CMOS technology by LSI Logic, and Linn Smart have a manufacturing deal with a major British printed circuit board maker to put the slot-in board into production.
Linn Smart have also developed a piece of software that runs on a Sun-3 workstation to simulate the behaviour of its board, although it cannot imitate the amazing speed of the device.
The market for embedding AI into conventional computers is enormous, but the prospects for Linn Smart's world-beating technology depend on how good a fight the company can put up against its United Stated rivals.

PEOPLE

On the 1 October last, the following took office at the IEE for the 1988/89 session:

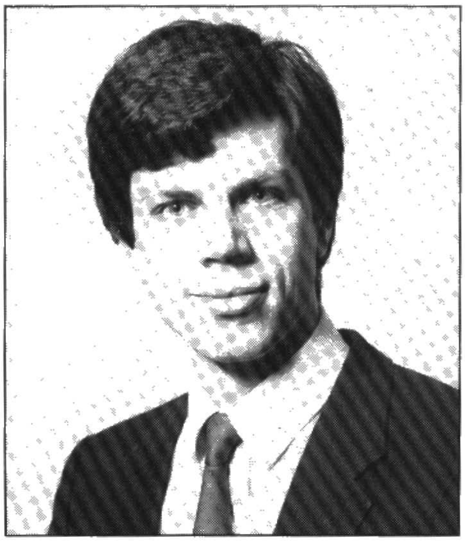
President — Dr T. Bryce McCrirrick, CBE, FEng, FIEE, formerly Director of Engineering, BBC.

Deputy Presidents — James C. Smith, CEng, FIEE, Chairman Eastern Electricity Board, and Dr. David A. Jones, CEng, FIEE, formerly Chairman, Ewbank Preece Consulting Ltd.

Divisional Chairmen —
Computing & Control Division: Dr. Nigel W. Horne, BSc(Eng), FEng, FIEE.
Science, Education & Technology Division: Professor Brian Makin, BSc(Eng), PhD, CEng, FIEE.
Electronics Division: Professor Jim R. James, BSc, PhD, DSc, FEng, FIEE.
Management & Design Division: Air Commodore Frank C. Padfield, CBE, BSc, CEng, FIEE.
Power Division: Mr William Fairney, CEng, FIEE.

The **Rt Hon The Viscount Weir**, Chairman, The Weir Group PLC, has been elected the 1988/89 President of BEAMA, the Federation of British Electrotechnical and Allied Manufacturer's Associations.

LSI Logic Corporation has established a Microprocessor Group and named **Brian Halla** as vice-president of the organization.

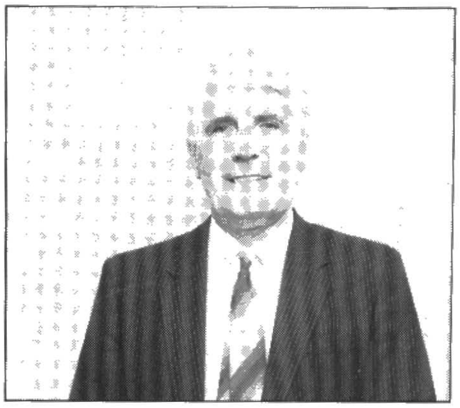


David Baillie has been appointed Director of Marketing Strategy for LSI Logic Europe PLC.

Gould Electronics have announced two senior management appointments. **Bill Trebinski**, formerly Director of Operations for Northern Europe, become Vice-President, Sales & Marketing; and **Chris Chant**, formerly Director of Marketing, becomes Director of Manufacturing.

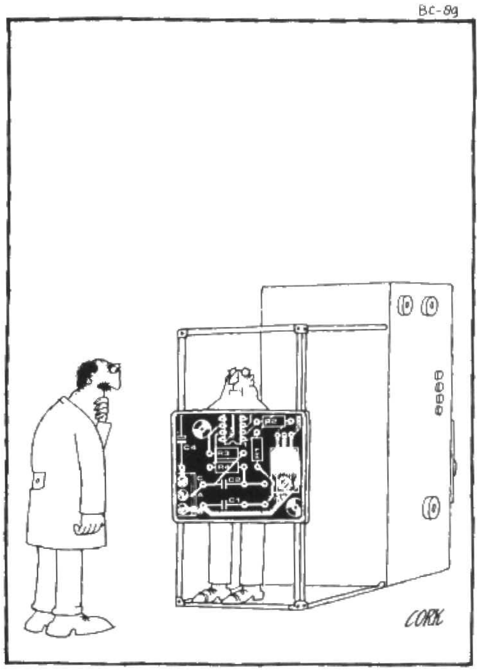
Mr John Mark, 53, has been appointed Technical Director of Marconi Radar Systems, Chelmsford.

Intel have announced the appointment of **Sean Maloney** as UK Regional Manager.



David Kingsley has been appointed as Technical Director of Graphic Electronics Group, the well-known printed-circuit board manufacturers.

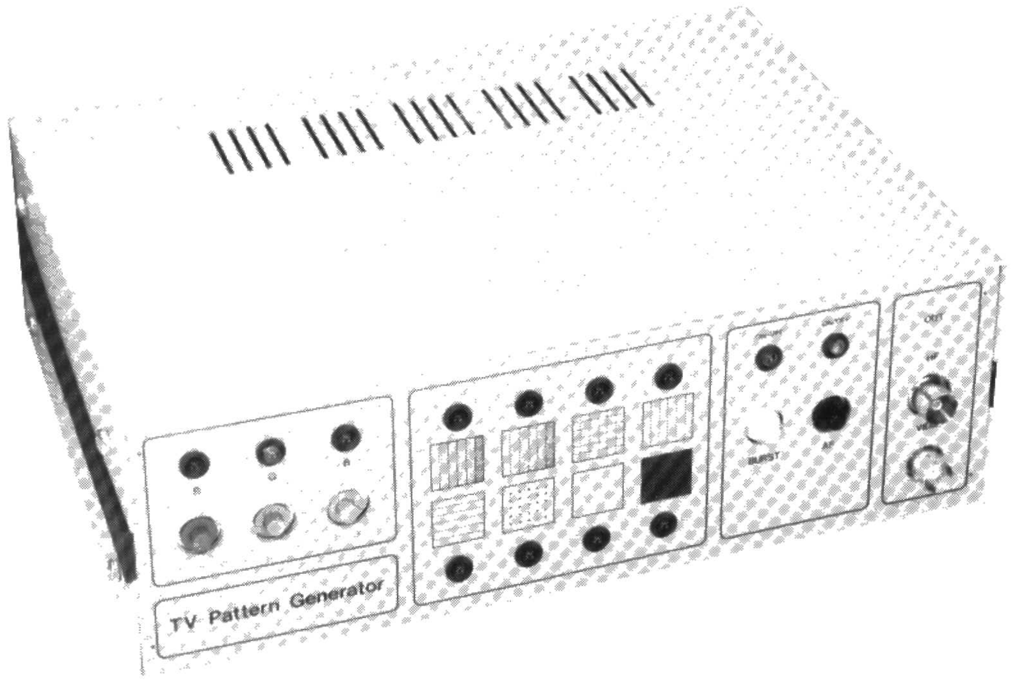
BC-89



COLOUR TEST PATTERN GENERATOR

from an idea by G. Kleine

A PAL-compatible colour video source that supplies a number of test patterns for aligning television sets.



A test pattern generator is virtually indispensable for troubleshooting in television sets because it supplies a video signal that is known to be stable, and thus easily displayed and synchronized on an oscilloscope. Moreover, the instrument allows the user to trace a fault in a TV set or other video equipment by selecting the most appropriate test pattern (e.g. a cross-hatch for convergence testing, or a dot pattern for focusing adjustment).

The test pattern generator discussed here is based on three integrated circuits: a pattern generator (ZNA234E from Ferranti), a video matrix chip with DAC inputs (LM1886) and an associated video modulator (LM1889). The latter two chips are manufactured by National Semiconductor.

Block diagram

The general set-up of the pattern generator is shown in Fig. 1. In principle, all patterns originate from the ZNA234E, which supplies the luminance information for a dot pattern (DOT), a cross-hatch pattern (XH), a horizontal line pattern and a vertical line pattern. The vertical bar pattern supplied by the chip is not used here because it is unsuitable for generating a colour staircase signal — this is derived from the vertical line pattern.

The output signal supplied by the pattern generator circuitry is monochrome, i.e., it contains only luminance information. Colour is obtained by applying the luminance signal to one or more inputs of the RGB generator. RGB signals are fed via two switches to a colour matrix. The first switch selects between the vertical bar pattern and the other patterns. The second switch disables the colour burst and thus allows the colour staircase to be made monochrome, i.e., to be converted to black, white and intermediary shades of grey. The other patterns can be viewed in black and white also by turning on red, green and blue simultaneously. The monochrome

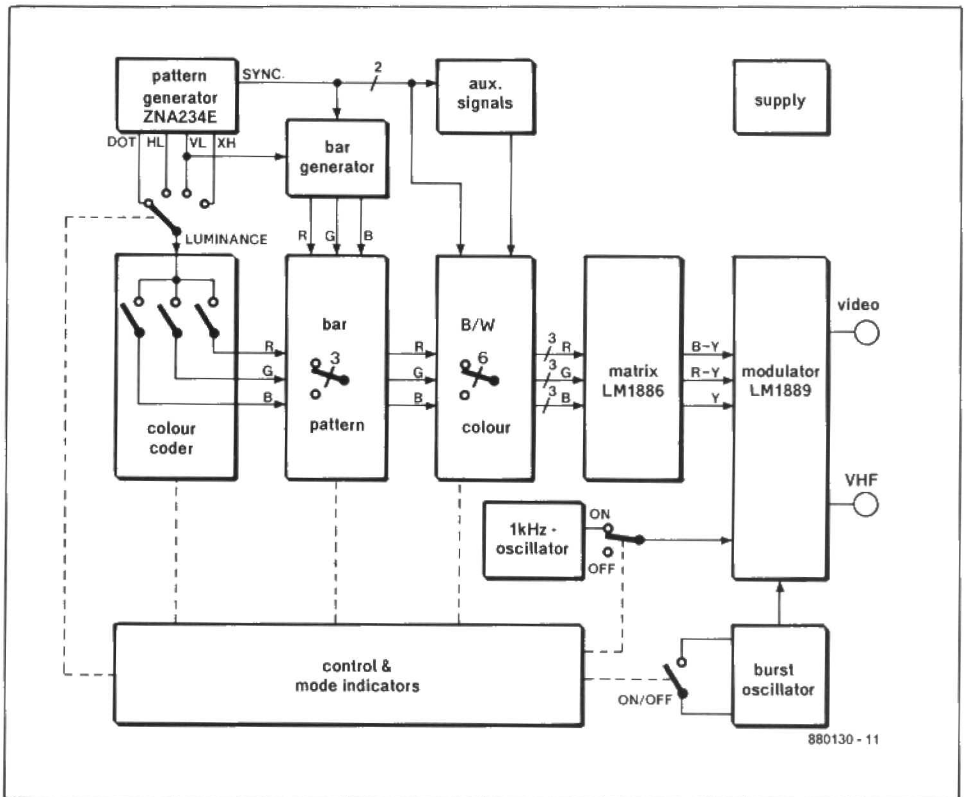


Fig. 1. Block diagram of the test pattern generator.

/colour switch provides the three 3-bit D-A inputs of the colour matrix with an RGB signal whose composition results in 8 colours or 8 shades of grey.
In the colour matrix, the RGB signal is translated into the corresponding levels for the luminance and chrominance component. Colour coding is essentially to the PAL (phase alternation line) standard. The LM1889 combines the signals supplied by the matrix with that of the colour burst generator. The composite video signal thus obtained is available at a buffered output. An RF modulator on board the LM1889 modulates the composite video signal plus a 1 kHz audio test tone on to a carrier in the VHF-1 band (approx. 48 to 65 MHz; now no longer used in the UK). An external UHF modulator is required for testing TV sets tuned to channels in the UHF band. The pattern generator provides a 625-line picture.

Circuit description

The circuit shown in Fig. 2 is not nearly as complex as it looks at first sight. In fact, it is fairly simple, and merely a combination of smaller sub-sections, whose basic function has been discussed above.
Circuit IC_3 provides the pattern signals and two synchronization signals, mixed sync (MS) and mixed video blanking (MVB). The switch that feeds the patterns to the colour generator is formed by IC_4, an 8-to-1 multiplexer. Actually, the circuit referred to as 'colour generator' is composed of three NAND switches, N_8, N_9 and N_{10}. The vertical bar pattern is generated by counter IC_5. Circuit IC_{12} is the vertical bar/pattern switch.
The monochrome/colour switch built around IC_{13}-IC_{14} drives the video matrix, IC_{18}, and the modulator, IC_{19}.
The 1 kHz test tone oscillator set up around T_2. This is switched on and off by the logic level at the Q_A output of IC_{5a} (0 = off; 1 = on). Preset P_1 is adjusted for optimum stability of the oscillator.
The burst oscillator on board the LM1889 operates at the PAL chrominance subcarrier frequency, 4.433 MHz, with the aid of an external quartz crystal and a capacitor network.
The user interface of the test pattern generator is formed by push-button switches S_3 to S_6. Each of these controls a function with the aid of a JK bistable (FF_3 to FF_6). Key debouncing is

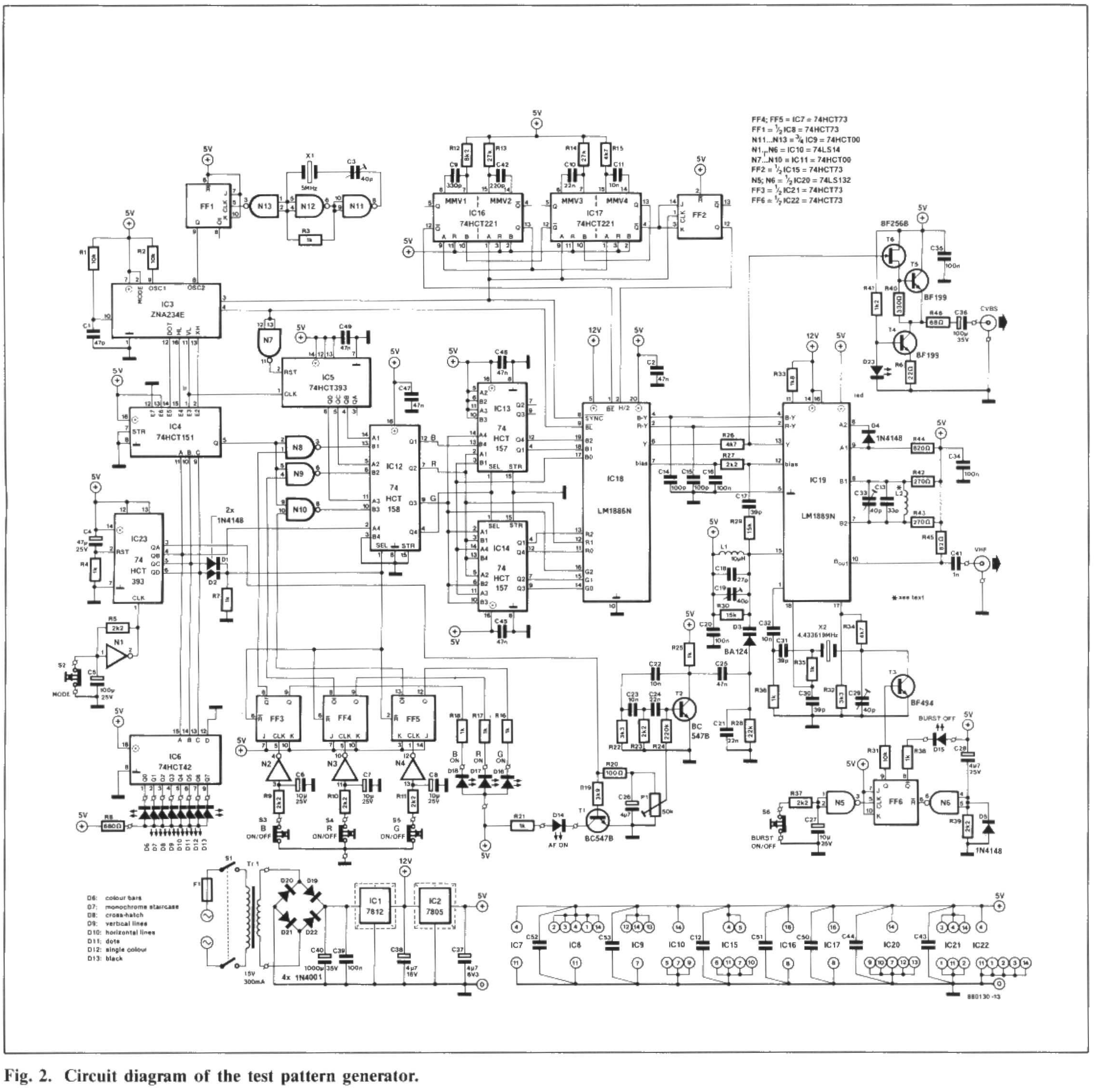
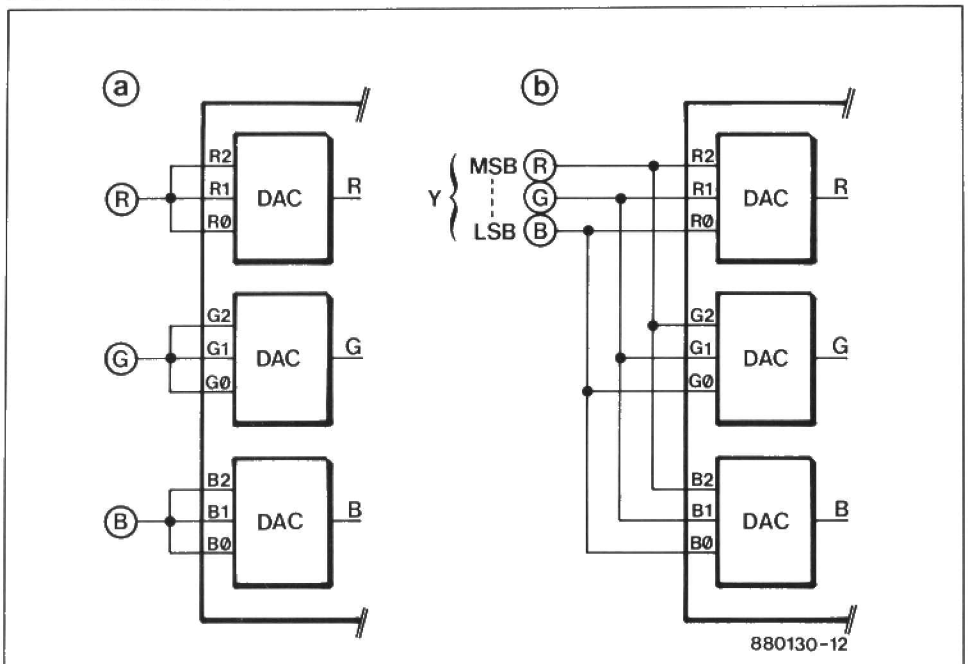


Fig. 2. Circuit diagram of the test pattern generator.



		R	G	B
	black	0	0	0
primary	blue	0	0	1
	green	0	1	0
	red	1	0	0
complementary	yellow	1	1	0
	magenta	1	0	1
	cyan	0	1	1
	white	1	1	1

	MSB	*	LSB
black	0	0	0
dark grey	0	0	1
dark grey	0	1	0
dark grey	0	1	1
dark grey	1	0	0
dark grey	1	0	1
light grey	1	1	0
white	1	1	1

Fig. 3. Electronic switches connect the RGB DACs in the LM1886 in two ways: as RGB-TTL inputs (Fig. 3a; colour), or as 3-bit intensity inputs (Fig. 3b; monochrome).

achieved with a combination of a Schmitt-trigger gate (N_2 to N_5) and an R-C network. The logic level at outputs Q and $\overline{Q}$ of each bistable toggles every time the associated key is pressed. LEDs connected to the bistable outputs show the currently selected mode of the pattern generator.

The pattern generated by the circuit is selected by S_2, whose debounced pulses clock counter IC_{5a}. An auto-repeat function is provided on S_2. The least significant bit supplied by the counter controls the 1 kHz AF oscillator, so that each pattern is available with or without a test tone. The three most significant counter bits control the pattern selector, the vertical bar/pattern switch, the monochrome/colour switch, and the pattern indicator formed by IC_6 and indicator LEDs D_6 to D_{13}.

Before the function of the control signals in the circuits is discussed, it is useful to examine the operation of the colour switch.

The simplified diagram of Fig. 3a shows the configuration of the six toggle switches (IC_{13}-IC_{14}) between IC_{12} and IC_{18}, when 'colour' is selected. Each basic colour has only two shades (saturation minimum or maximum), since the inputs of each DAC are interconnected. For test purposes, this arrangement still results in enough colour combinations.

The switch configuration for 'monochrome' is shown in Fig. 3b. The inputs are connected such that only one 'colour', white, is available, but the intensity can be controlled to give grey and black — the RGB information applied is simply used as a 3-bit luminance (Y) signal.

Returning to the control circuitry of the test pattern generator, D_1, D_2 and R_7 provide an OR function that controls the vertical bar/pattern selector, IC_{12}. A logic high level supplied by D_1-D_2-R_7 selects the RGB signal from gates N_8 to N_{10}; a logic low level, the signal from the vertical bar generator. The fourth switch contact in IC_{12} controls the monochrome/colour selector. When IC_{12} is set to 'pattern', IC_{13} and IC_{14} are set to the 'colour' position (note that this does not exclude a monochrome picture, since red plus green plus blue gives white). When IC_{12} is set to 'pattern', the monochrome/colour and colour selection depends on the logic level at the Q_B output. When this is low, IC_{13} and IC_{14} are in the 'colour' position, so that the colour bars are generated. A high level at Q_B selects the staircase signal for monochrome applications.

As already noted, the bar pattern (monochrome as well as colour) is derived from the signals supplied by IC_3. The pattern is basically generated by the luminance signal for the vertical line pattern, which is composed of a number of pulses at fixed intervals in each line. These pulses are used for clocking a 4-bit counter. Since the three most significant bits function as RGB outputs, the colour obtained changes with every second pulse applied to the clock input. The RGB information remains the same in between two pulses, so that a coloured bar is obtained. Between two lines IC_{5b} is reset by the inverted MVB signal (N_7) to ensure that the counter has the same start state (nought) at each line.

Signals burst enable, $\overline{BE}$, H/2, and a bias signal are combined with the available RGB signals in IC_{18}. The chrominance subcarrier generated by IC_{19} is applied to the bias input, pin 7, of IC_{18}. The other two signals, $\overline{BE}$ (burst key) and H/2, are obtained with the aid of monostables MMV_1 to MMV_4, and bistable FF_2. Signal H/2 is the line toggle signal that inverts the R–Y signal for each line in the PAL picture. FF_2 is synchronized by MMV_4 to

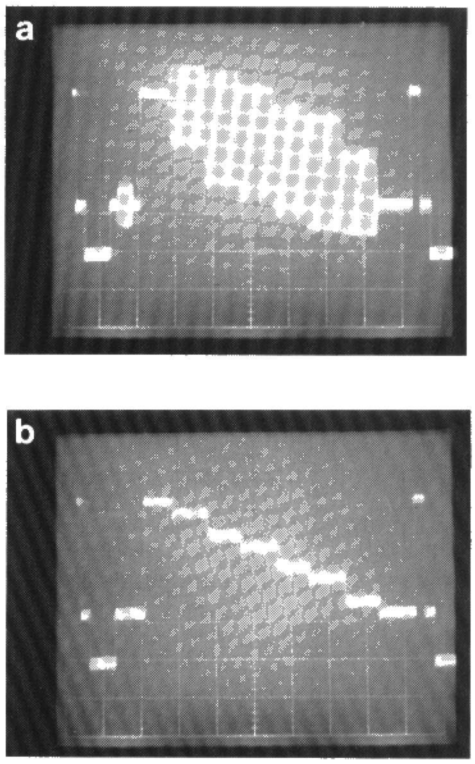


Fig. 4 Oscilloscope photographs showing one picture line in the colour bar pattern (Fig. 4a) and one picture line in the monochrome staircase pattern (Fig. 4b).

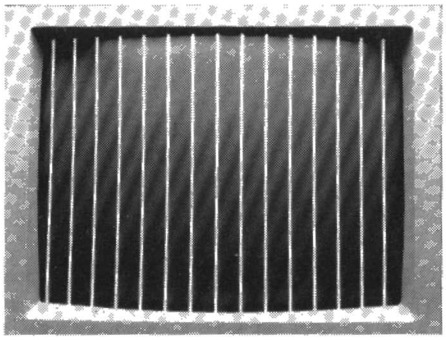
ensure that the temporarily doubled horizontal sync-pulse rate in the vertical sync interval does not upset the PAL timing.

The Y-output of IC_{18} carries a colour CVBS (composite video, blanking, synchronization) signal. The photographs in Fig. 4 show oscillograms of one picture line in the colour bar pattern (Fig. 4a), and one line of the monochrome staircase pattern (Fig. 4b). The CVBS signal is buffered by an amplifier around T_4 to T_6, to enable driving a 75 Ω load.

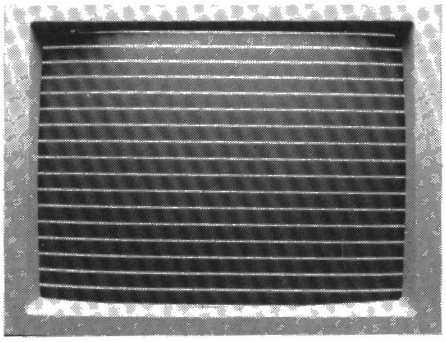
Unfortunately, the RF modulator contained in the LM1889 can only operate at VHF Band 1 channels (2 to 4). Vestigial sideband suppression is not provided — the RF spectrum generated is simply that of a DSB (double-sideband) modulator. The frequency of oscillation is determined by an external L-C tank circuit, C_{13}-C_{33}-L_2. The modulator is driven with the CVBS signal and the FM sound carrier, whose frequency is set to 6.0 MHz (UK) or 5.5 MHz. Like the chrominance and the RF carrier oscillators, the sound subcarrier oscillator is also contained in IC_{19}. Frequency modulation is achieved with the aid of varicap D_3 which forms part of an external L-C tuned circuit, L_1-C_{18}-C_{19}.
Switching between a colour and monochrome picture is effected by pressing the BURST ON/OFF button (toggle function). The quartz-crystal controlled chrominance subcarrier oscillator is disabled when T_3 conducts.

Construction

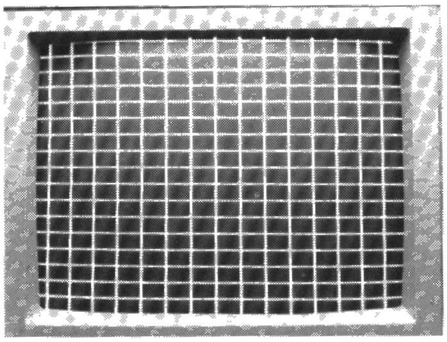
The printed circuit board for the test pattern generator, shown in Fig. 5, is a double-sided, but not through-plated, pre-tinned type with a large ground plane at the component side to keep digital interference within limits. All integrated circuits are fitted on to the PCB *without IC sockets*. In some cases, component terminals (including IC pins) are soldered at both sides of the board to effect through-contacting.
Commence the construction with installing 11 short pieces of through-contacting wire in the vicinity of the boxed EPS number at the component side. Mount and solder one component at a time, and check that pins or terminals, where appropriate, are soldered at both PCB sides. Use a soldering iron with a fine tip.
RF inductor L_2 consists of 6 turns of 1 mm dia. (SWG20) enamelled copper wire. The internal diameter is about 6 mm. Space the turns evenly so that the wire ends can enter the holes provided. The photograph of the prototype in Fig. 6 shows that the RF section of the circuit is screened with 20 mm high tin-



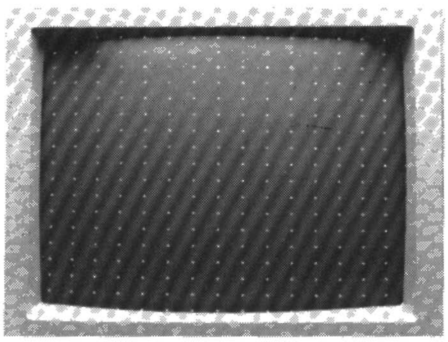
Vertical lines.



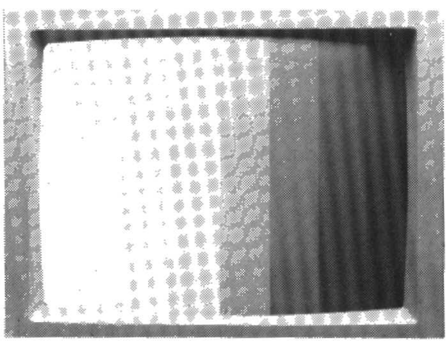
Horizontal lines.



Cross-hatch pattern.



Dots.



Monochrome staircase pattern.

Faultfinding in TV sets

A test-pattern generator is a video signal source intended for locating malfunctions in TV sets and video equipment. Below are a number of possible applications of the instrument described in this article.

Convergence:
Convergence is the intersection, at a specific point at the inside of the multibeam picture tube, of the R (red), G (green) and blue (B) electron beams. Convergence errors are usually observed as beam divergence in the picture corners, where an originally white, single, line diverges in two or more, coloured, lines.
Required test-patterns: cross-hatch or vertical lines.

Focusing:
Focusing and convergence adjustments usually interact, but may use different circuits in the TV set. An improperly focused picture appears blurred and hazy. Like convergence, focusing may have to be optimized with the aid of separate adjustments that work on parts of the screen.
Required test-patterns: dots, cross-hatch and vertical lines.

RGB amplifiers:
Given that the picture tube still has equally active R, G and B emitters, these should have closely matched DC amplification characteristics to prevent colour distortion.
Required test-pattern: colour bar (luminance of individual colours decreases: white, yellow, cyan, green, magenta, red, blue, black).

Uniform saturation on whole screen:
The background colours without a test-pattern enable checking for uniform colour saturation in all areas of the screen. Light spots point to ageing effects in the picture tube.

Burst:
A monochrome picture is generated when the colour burst is turned off. This ability of the pattern generator may be useful for troubleshooting the colour demodulator and chrominance circuits.

Parts list

Resistors (±5%):
R1;R2;R31 = 10K
R3;R4;R7;R16;R17;R18;R21;R25;R35;R36;
R38 = 1K0
R5;R9;R10;R11;R23;R27;R37;R39 = 2K2
R6 = 22R
R8 = 680R
R12 = 8K2
R13;R14 = 27K
R15;R26;R34 = 4K7
R19;R22;R32 = 3K3
R20 = 100R
R24 = 220K
R28 = 22K
R29;R30 = 15K
R33 = 1K8
R40 = 330R
R41 = 1K2
R42;R43 = 270R
R44 = 820R
R45 = 82R
R46 = 68R
P1 = 50K preset H

Capacitors:
Notes:
All ceramic capacitors (<1 nF): pitch 5 mm.
All electrolytic capacitors: radial unless otherwise noted.
C1 = 47p
C2;C12;C25;C43 . . . C53 incl. = 47n
C3;C19;C29;C33 = 40p foil trimmer
C4 = 47μ; 25 V
C5 = 100μ; 25 V
C6;C7;C8;C27 = 10μ; 25 V
C9 = 330p
C10;C21;C24 = 22n
C11;C22;C23;C32 = 10n
C13 = 33p
C14;C15 = 100p
C16;C20;C34;C35;C39 = 100n
C17;C30;C31 = 39p
C18 = 27p
C26 = 4μ7; 25 V
C28;C37;C38 = 4μ7; 25 V; axial
C36 = 100μF; 35 V
C40 = 1000μF; 35 V
C41 = 1n0
C42 = 220p

Semiconductors:
D1;D2;D4;D5 = 1N4148
D3 = BA124 or BB109G
D6 . . . D15 incl.;D23 = LED 5 mm (rectangular LEDs possible for D6 to D13)
D16 = LED; 5 mm; green
D17 = LED; 5 mm; red
D18 = LED; 5 mm; yellow (blue preferred)
D19 . . . D22 incl. = 1N4001
T1;T2 = BC547
T3 = BF494
T4;T5 = BF199
T6 = BF256B
IC1 = 7812
IC2 = 7805
IC3 = ZNA234E (Ferranti)+
IC4 = 74HCT151P
IC5;IC23 = 74HCT393P
IC6 = 74HCT42P
IC7;IC8;IC15;IC21;IC22 = 74HCT73P
IC9;IC11 = 74HCT00
IC10 = 74LS14
IC12 = 74HCT158P
IC13;IC14 = 74HCT157P
IC16;IC17 = 74HCT221P
IC18 = LM1886N+
IC19 = LM1889N+
IC20 = 74LS132

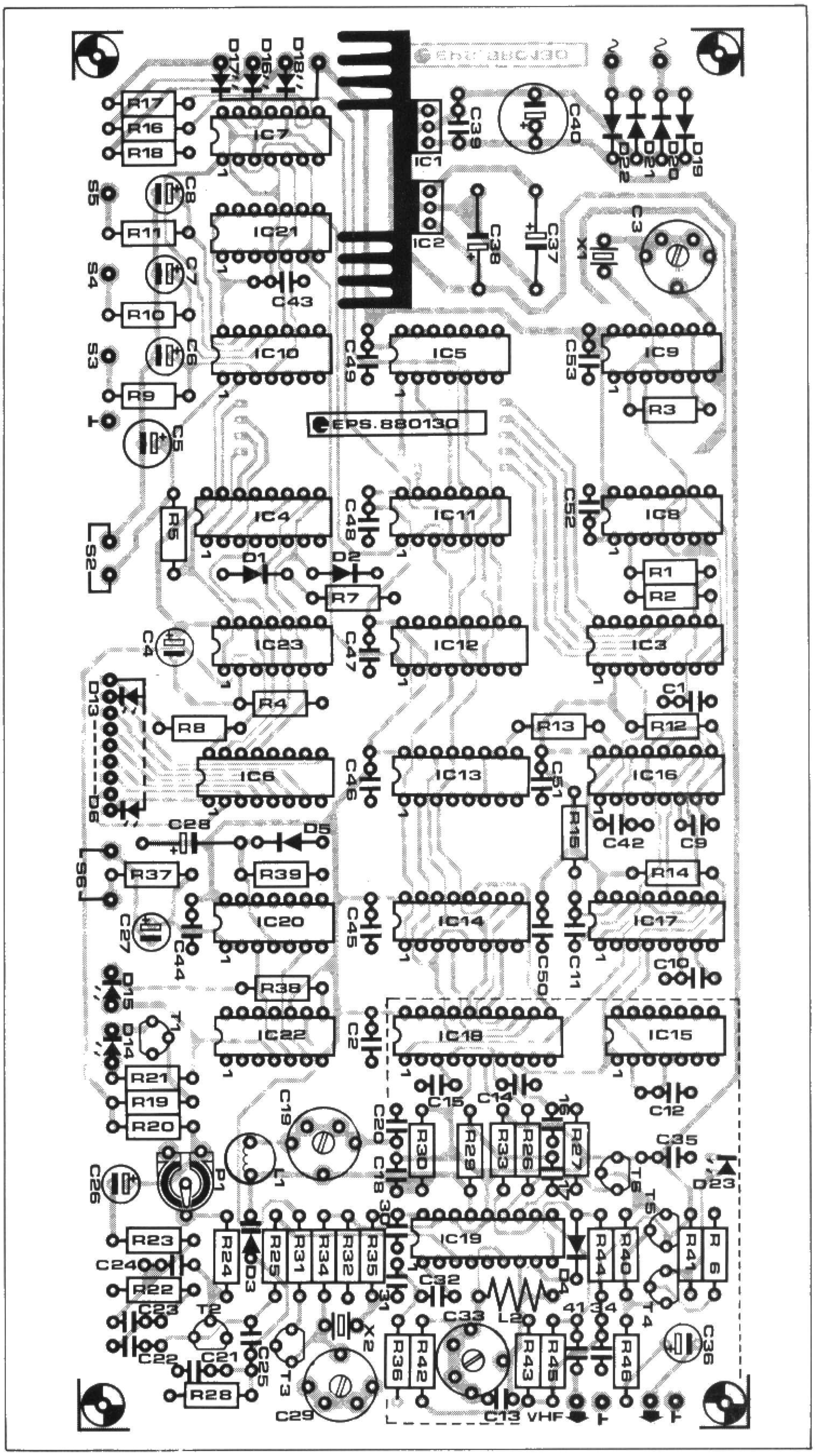


Fig. 5. Component mounting plan of the double-sided printed circuit board.

+ Listed by Cricklewood Electronics and Universal Semiconductor Devices.

Inductors:
L1 = 10μH
L2 = home-made inductor; see text

Miscellaneous:
S1 = double-pole mains switch in mains entrance socket with built-in fuseholder.
S2 . . . S6 incl. = push-to-break button.
X1 = 5 MHz quartz crystal in HC18 enclosure.
X2 = 4.433619 MHz quartz crystal in HC18 enclosure.
BNC socket.
Common heat-sink for IC1 and IC2.
Fuse: 100 mA delayed action.
Mains transformer 15 V; 400 mA.
Metal enclosure: approx. size 25×8×18 cm.
TV coax socket.
PCB Type 880130 (see Readers Services page).

plate sheets, which are joined in the corners, and soldered on to the ground plane. The screen that runs along IC_{14}-IC_{17} and IC_{18}-IC_{15} can only be soldered in the corners and close to C_{10} because of the tracks running beneath it. Trimmer C_{29} is to be mounted a few millimetres above the board surface to prevent overheating of the PTFE foil when the two rotor connections are soldered to the ground plane.
Finally, on ready-made board 880138, connect pins 1, 2, 3 and 14 of IC_{22}, and pin 1 and 2 of IC_{21}, to ground.

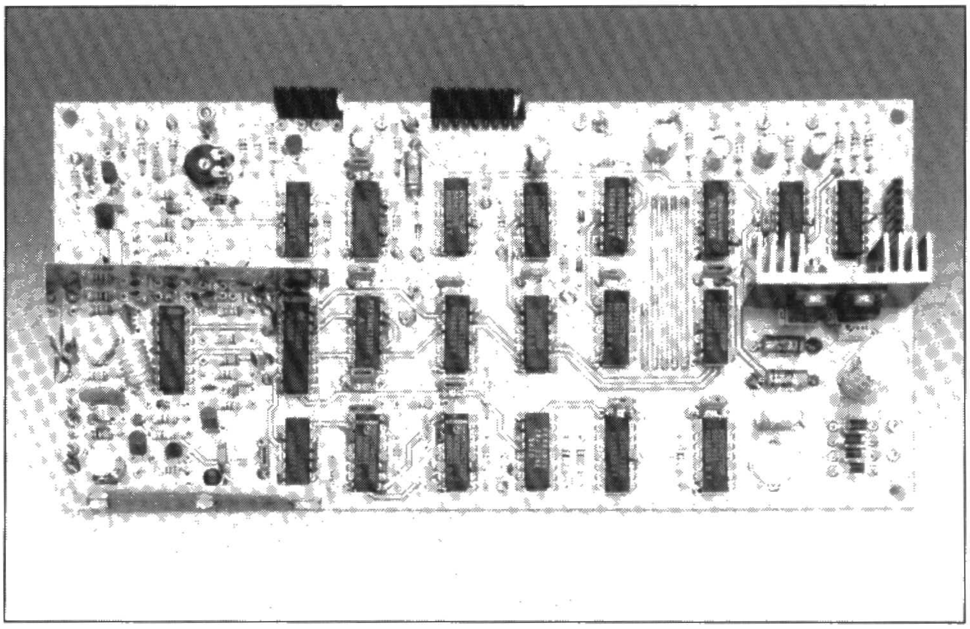


Fig. 6. The completed board (prototype). Note the screening around the RF sections.

Setting up

The video part of the test pattern generator is fairly simple to adjust. Connect a colour monitor with a 75 Ω CVBS input to the corresponding output of the circuit. Set all trimmers to the centre of their travel, and turn the wiper of P_1 to ground. Press the BURST ON/OFF key when D_{15} lights. Carefully adjust trimmer C_{29} for minimum interference between the coloured bars.

As already noted, the VHF modulator is only for use with a TV set on which VHF Band 1 is available.
Tune the TV to, say, channel 3 (in Europe, TV channel E3 = 55.25 MHz). Adjust C_{33} until the test pattern appears. If available on the TV set, use the fine adjustment to obtain a clear picture; otherwise, carefully adjust C_{33} with an insulated trimming tool. Turn up the volume on the set and adjust C_{19} for minimum AF noise. This tunes the sound oscillator to the correct subcarrier frequency (6.0 MHz or 5.5 MHz, depending on the country you live in). Press S_2 if D_{14} does not light. Carefully advance P_1 until the test tone is heard in the receiver. Increase the frequency and the volume by turning P_1, up to a point where the tone becomes unsteady. Turn the wiper back until the steady tone is restored at maximum volume.

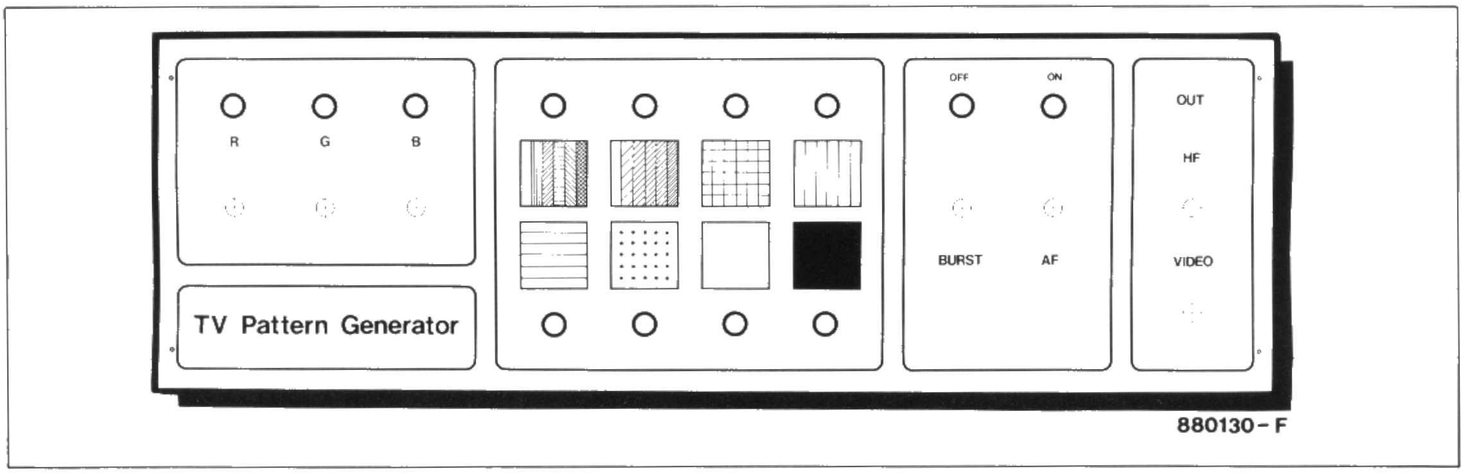


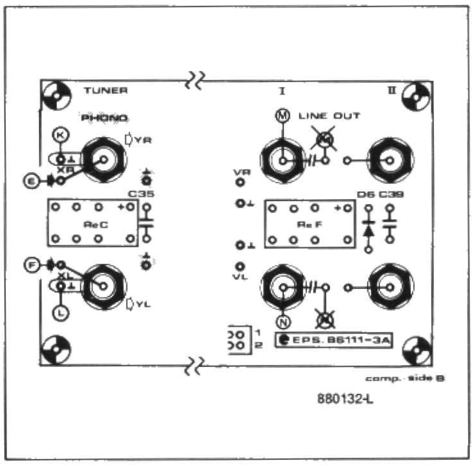
Fig. 7. Suggested front panel layout.

CORRECTIONS

Preamplifier for purists

October 1988, p. 30-36.

In the top drawing of Fig. 4, the 47 pF capacitor across R_{31} should be labelled C_{25}, not C_{24}. In the lower drawing, the 47K5 resistor to the left of R_{38} should be labelled R_{37}.
The accompanying diagram shows the corrected component mounting plan of busboard 1 (Fig. 6 on p. 33). Note the placement of points M and N, and the connections between the tuner input terminals and points E and F.



Macrovision decoder/blanker

October 1988, p. 44-47.

The HSYNC LED, D_5, may fail to light even when a video signal of sufficient amplitude is applied. This can be resolved by replacing the Type 7805 voltage regulator in position IC_4 with an 7806 or 7808, which have the same pinning. The use of an 7808 requires R_{14} to be increased to 15 kΩ.

New Literature

C

by Mike Burgess
ISBN 1 870336 16 X
512 pages — 210×145 mm
Price £14.95 (soft cover)

C, a book in the *A Dabhand Guide* series, will give even relatively unexperienced programmers a clear understanding of programming in C. In no fewer than 37 chapters, the book describes all possibilities contained in this high level language.

The book is, of course, not dedicated to any one computer, because C is a universal programming language that has to be translated in a compiler into the actual program for a particular computer. It is because of this that users of not only an IBM PC or compatible, but also of a Commodore Amiga, an Atari ST, a BBC Micro, and an Archimedes, to name but a few, will find much valuable information.

Unlike the situation with hardware, characterized by a lack of standardization, that in regard of software is much better, and this book shows it. Where there are differences in the compiler, the reader is given a helping hand by the additional options given in the book.

Optionally available is a programmed floppy disk that contains the programs described in *C*. This disk is supplied with a short manual.

Mark Burgess holds an Honours Degree in Theoretical Physics. He writes computer programs in over half a dozen languages of which C is his favourite. He is the inventor of the Burgess Program Structuring which is explored in this book.

Dabs Press (RU) • 76 Gardner Road • Prestwich • MANCHESTER M25 7HU.

Musical Applications of the Atari STs

by R.A. Penfold
ISBN 0 85934 191 7
90 pages — 263×193 mm
Price £5.95 (soft cover)

With its built-in MIDI ports, large memory, excellent graphics, high processing power, it is, perhaps, not surprising that the Atari STs, according to most insiders, are now ***the*** computers to use for electrophonic music applications. The range and sophistication of these applications are greater than most people may realize. This book will help them get the most, musically that is, from the STs.

The book is intended for the musician who wants to exploit the potential of the ST computers in music applications. As that usually means using the ST in MIDI systems, much of the book is devoted to a description of MIDI in general, MIDI as it applies to the ST, and running MIDI applications on the ST.

The book assumes only a basic knowledge of running software on an ST. None the less, more technically minded readers who like the do-it-yourself approach will find chapters covering hardware projects, programming the ST's sound chip, and MIDI programming.

BERNARD BABANI (publishing) LTD • The Grampians • Shepherds Bush Road • LONDON W6 7NF.

Soldering Handbook

by Ray Skipp
ISBN 0 632 02064 4
188 pages — 240×160 mm
Price £29.95 (hardback)

Soldering is a basic and indispensable process for all involved in electronics. This thoroughly practical book is intended to guide engineers and technicians through the various soldering systems, to guide them towards the correct system to be used and to help avoid pitfalls and solve the problems that will occur along the way. It will also be of great help to all involved in electronic quality control.

In 12 chapters, the books covers, among others, the theory of soldering, hand soldering, flow soldering, surface mount assembly soldering, de-soldering techniques,and the cleaning of printed-circuit boards.

The book is structured in a logical sequence, starting with simple manual soldering techniques, and progressing through flow soldering systems to the latest microelectronic soldering techniques.

Ray Skipp has been involved directly with the setting up and running of practical quality control systems in a number of electronics companies, both as a quality manager for many years, and for the past nine years as a consultant.

BSP Professional Books • Osney Mead • OXFORD OX2 0EL.

ARCHMIDES ASSEMBLY LANGUAGE

by Mike Ginns
ISBN 1 870336 20 8
368 pages — 210×145 mm
Price £14.95 (soft cover)

This book, one of the *A Dabhand Guide* series, covers all aspects of machine code/assembler programming for the Archimedes range.

In 24 chapters, the book describes the ARM (Acorn RISC) processor used in the Archimedes, the machine language for various applications, such as I/O, graphics, dataprocessing, and so on.

There is also a large section on the powerful assembler incorporated in the BASIC of the Archimdes, and thus accessible to all users of the computer.

The contents make the book a welcome addition to the manual provided with the computer and will, no doubt, be an invaluable source of information for many owners of an Archimedes.

Optionally available is a programmed floppy disk that will give further evidence of the power of the assembler.

Mike Ginns, who read computer science at Reading University, has been programming the BBC Micro and many other computers in assembly language for many years.

Dabs Press (RU) • 76 Gardner Road • Prestwhich • MANCHESTER M25 7HU

Remote Control Handbook

by Owen Bishop
ISBN 0 85934 185 2
226 pages — 178×110 mm
Price £3.95 (soft cover)

This book is more than an update of *Remote Control Projects* published eight years ago: in view of the many advances in electronics in the intervening years, it has become a virtually new book. None the less, it retains some of the well-tried and tested circuits for which components are still available today.

A number of circuits in the book have not been published before. Many of these are concerned with aspects of remote control that have increased in importance over the past few years. In particular, there are circuits for interfacing microcomputers to remote control systems, for using fibre optics, and for using the domestic mains wiring system as transmission links. There are also circuits for stepper motors, voltage-to-frequency conversion and frequency-to-voltage conversion.

The book assumes that readers are already familiar with the mechanical aspects of the devices they wish to control, and it is, therefore, restricted to the electronic aspects of remote control.

BERNARD BABANI (publishing) Ltd • The Grampians • Shepherds Bush Road • LONDON W6 7NF.

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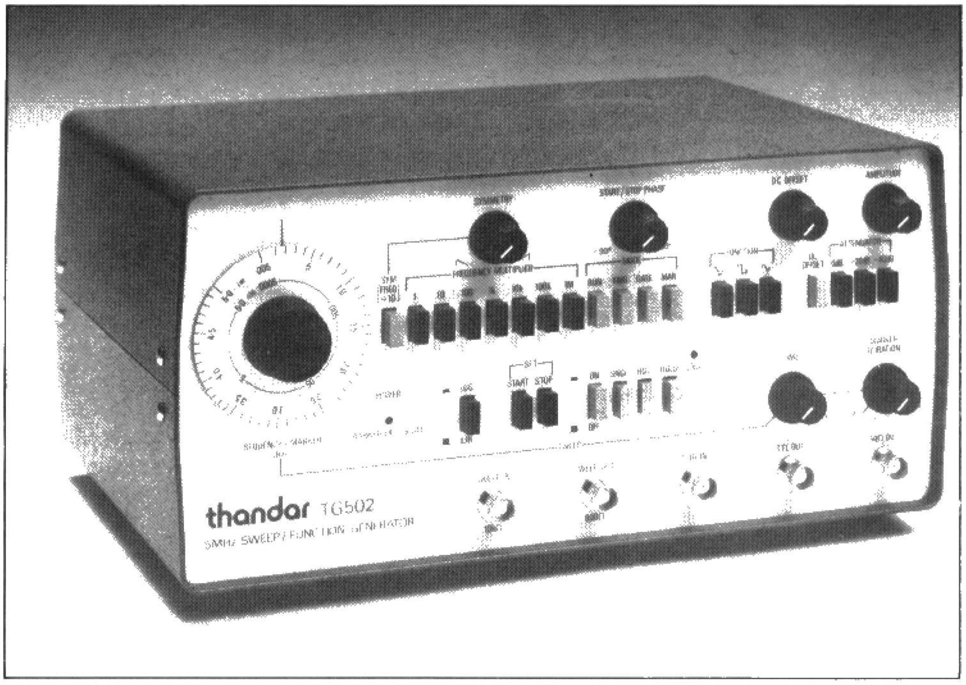
TEST & MEASURING EQUIPMENT

Part 12: Signal Generators (6)

by Julian Nolan

Thandar TG502



The Thandar TG502 represents an intermediate step between the low-cost 2 MHz signal sources and the vastly more expensive synthesized generators that start at around £1500. The price of the TG502 is £495.

The TG502 is one of a family of three: the TG501 is a basic model, priced at £325, while the TG503 priced at £545, provides pulse generator as well as all the other facilities of the TG502.

The TG502 is connected to the mains by a standard IEC socket. The mains voltage may be 100-120-220-240 V: selection is by means of interchangeable taps on the mains transformer.

Main generator. The continuously variable output frequency is read from a linear/logarithmic scale that covers a range of 1000:1 and 10,000:1 respectively. The frequency range is specified as 5 mHz to 5 MHz, although the review model extended up to 6.3 MHz. The accuracy of the vernier control is fairly good, except at the mid-point of the scale where the specified error of ±5% was approached. Only approximate gradations are available on the logarithmic scale.

Range selection is by seven pushbutton switches, covering multiplying coefficients of 1 to 1 million.

Symmetry control is available only up to 500 kHz since when this facility is operated the output frequency is divided by 10.

Output level performance is good. Switched attenuators are provided that give the standard −20 dB and −40 dB reduction in output amplitude to complement the variable control. This permits the output levels to be set as low as 8 mV_{pp} into 50 ohms, and up to 20 V_{pp} e.m.f.

Noise levels are low at all output levels. A d.c. offset control is provided which operates at the obligatory 50-ohm output.

A TTL output is also provided: the rise/fall time is about 10 ns.

The TG502 offers an impressive range of operating modes for an instrument in this price range, including triggered, gated, manual, and continuous. The start/stop phase is variable over two quadrants. Performance in all these modes is good, which makes the TG502 suitable for use in a wide range of applications.

Distortion is fairly good: on the review model 0.5% up to 95 kHz, increasing to 1% at 620 kHz.

Sine wave output flatness is good at ±0.2 dB up to 500 kHz and ±1 dB to 5 MHz.

In addition to the three main waveforms—sine, triangle and square—a d.c. output is available.

Sweep generator. The sweep section incorporated in the TG502 should satisfy most users. It offers a wide range of functions and a good level of versatility. The sweep range extends to 1000:1 or 10,000:1 in the linear and logarithmic sweep modes respectively. Both sweep start and stop frequencies can be set, as well as the sweep rate, which may be varied from 20 ms to 120 s. A higher sweep rate of, say, 5 ms might have been useful for some applications. Sweeps may be single or continuous: a hold mode is available that stops the sweep at its instanteous value.

A marker is also available to halt the sweep for a preset time. This is useful when the sweep generator is used with an oscilloscope to measure, for instance, a filter response, when a number of positions on the response curve require highlighting.

The generator provides inputs for an external sweep reset and hold, and outputs for sweep output and pen lift for a plotter. There is also a sweep input for situations where sweeps conforming to functions different from the built-in ramp are required.

Construction. As may be expected from Thandar, no compromises have been made in the construction of the TG502. External construction is based on a two-piece metal enclosure with steel end-plated. This gives the instrument a justifiably solid appearance and should enable it to be used in a wide range of environmental conditions.

Front panel layout is good, alhough several control positions take some getting used to.

Outputs, such as the marker function, are located at the back of the instrument.

Although the design of the enclosure does not really enable it to be stacked,

Table 17

TECHNICAL SPECIFICATION

Main generator	
Frequency range:	0.005 Hz to 5 MHz in 7 decade ranges; vernier accuracy ±5%.
Sine wave distortion:	<0.5% to 50 kHz, <1% to 500 kHz; all harmonics >30 dB below fundamental in 1 MHz range; flatness ±0.2 dB to 500 kHz, ±1 dB to 5 MHz.
Triangle:	linearity >99% to 500 kHz.
Square wave:	symmetry ±1% to 100 kHz; rise/fall time >45 ns.
Operating modes:	continuous, gated and manual.
Inputs:	sweep sensitivity 0 to 4 V for 1000:1 (linear) sweep; max. slew rate 0.1 V/μs.
Trigger input:	DC to 5 MHz; TTL compatible; start/stop phase variable ±90°.
Outputs:	50 ohms; switched attenuator 0 dB, −20 dB and −40 dB; variable attenuator 0 dB to >−20 dB; peak level 20 V_{pp} e.m.f. or 10 V_{pp} into 50 ohms; DC offset control ±10 V e.m.f.; TTL output can drive 20 loads.
Sweep generator	
Range:	10,000:1 (logarithmic) or 1000:1 (linear).
Controls:	sweep limits; reset; single sweep; hold; on/off.
Sweep rate:	20 ms to 120 s.
Marker:	duration variable from 10 ms to 10 s; frequency set bu vernier control.
Annunciators:	reset; hold; end; marker off scale.
Inputs:	sweep reset and hold.
Outputs:	sweep and pen lift.
Miscellaneous	
Input voltage:	100-120-200-240 V 50/60 Hz a.c.
Accessories:	mains lead; manual.
Dimensions:	300×145×230 mm (W×H×D)
Weight:	4.2 kg.

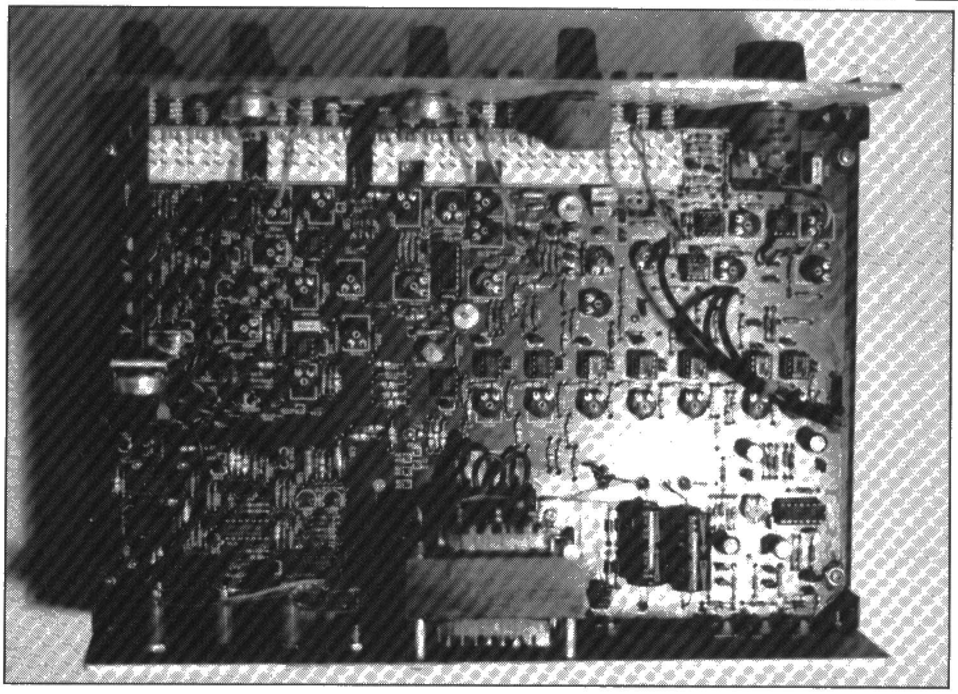


Table 18

	Unsatis-factory	Satis-factory	Good	Very good	Excellent
Dial accuracy				*	
Dial resolution					*
External sweep range					*
Distortion				*	
Frequency range					*
Output level range				*	
Internal construction					*
External construction				*	
Overall specification				*	
Ease of use					*
Manual					*
Additional features				*	

this should not affect the ease of use of the instrument.

The well-thought-out internal construction is based on two double-sided fibreglass PCBs. Access to both these boards is good, which should make any servicing quite easy. Heat dissipation on the boards is low.

The operating manual is fairly extensive and includes detailed sections on operating modes, sweep generator functions and a number of applications. No circuit diagram or servicing information is given, but a service manual is available as an optional extra.

Conclusion. The TG502 is a mid-range instrument providing a good blend of low cost and performance. Its sweep facilities are particularly notable as are its triggering options. A higher sweep rate, coupled perhaps to sweep waveforms other than the ramp, would have been useful for some applications. The sweep generator is, however, very easy to use.

The frequency range of 5 mHz to 5 MHz and the TTL output make the TG5502 suitable for use on digital equipment. If that is the primary requirement, however, the TG503 should be considered.

Construction of the instrument is good and this, together with its good perfor-make, should make the TG502 ideal for use in a wide range of applications.

The review model of the TG502 was supplied by the makers, Thandar Electronics Ltd, London Road, St. Ives, HUNTINGDON PE17 4HJ, Telephone (0480) 64646.

Other function generators available in the Thandar range are

TG101 — reviewed in the June 1988 issue of *Elektor Electronics*; price £110, excl. VAT.

TG102 — reviewed in the June 1988 issue of *Elektor Electronics*; price £160, excl. VAT.

TG501 — 5 mHz to 5 MHz; triggered and gated modes; variable stop/start phase; DC offset; TTL output; distortion <0.05% to 50 kHzl RRP £325, excl. VAT.

TG503 — similar to TG501 but with added pulse generator; double pulse mode permits max. frequency of 10 MHz; symmetrical positive- or negative-going outputs with adjustable baseline; delayed pulse also available; RRP £545, excl. VAT.

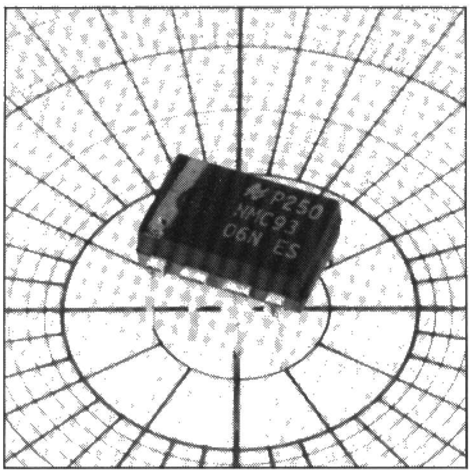
TG105 pulse generator — 5 MHz to 5 MHz, gated and triggered modes; square wave plus complement; TTL and sync outputs; RRP £105, excl. VAT.

BACKGROUND TO E²PROMS

Memory chips with large storage capabilities invariably steal the limelight these days. There are, however, many interesting low-capacity devices available as well. One of these is the electrically erasable programmable read-only memory – E²PROM. Its low cost, versatility and ease of programming make this device an ideal component for many applications involving the permanent storage of, for instance, instrument configuration data.

As an example of the operation and application of a typical E²PROM (or EEPROM), this article discusses the 256-bit Type NMC9306 from National Semiconductor. Readers of this magazine will recognize this device from the *Microcontroller-driven power supply* (Ref. 1), where it is used to for storage and retrieval of voltage and current settings associated with 3 user-selectable instrument configurations.

Basically, an E²PROM couples the non-volatily of an EPROM to the flexibility of a RAM. In this sense, it is functionally similar to a RAM with battery back-up, or a zero-power RAM (e.g. the 48Z02). Among the advantages of the E²PROM discussed here are its low cost and simple-to-use serial interface, which is of particular interest when the device is to be incorporated in existing systems.



Component availability note:
The NMC9306 is available from ElectroMail, P.O. Box 33, Corby, Northants NN17 9EL. Telephone: (0536) 204555. Stock number: 301-656.

Features and applications

An E²PROM is a read-only memory, and can, in principle, only be read from. Its special internal configuration, however, makes it possible to erase the device *electrically*, and re-load it, during normal operation. This obviates the need for exposure to ultraviolet light, and the application of a high programming voltage, required for erasing and programming a conventional EPROM. The NMC9306 is fed from a single supply voltage, 5 V, and has an on-chip step-up converter that supplies the programming voltage. Each of the sixteen 16-bit registers can be erased individually. An important difference with respect to a conventional RAM is, however, the time needed for loading (=writing to) a register. In the case of the NMC9306, this programming cycle takes at least 10 ms per register. Also, the number of write operations is limited to about 10,000 per register. The maximum guaranteed data retention period is 10 years, so that data will need to be 'refreshed' at least once during this time, by means of a erase-write cycle.

As already noted, the E²PROM is ideal for quasi-permanent storing of equipment configuration data. As an example of that application, Philips Test Instruments fit a number of their top-grade frequency meters with an E²PROM that holds data corresponding to the temperature response of the central quartz crystal built into a temperature-compensated oven. The temperature coefficient of each quartz crystal intended for use in these instruments is individually recorded as a curve, which is then digitized and loaded into the E²PROM. The microprocessor that controls the instrument measures the temperature of the oven, loads the relevant temperature coefficient from a look-up table, and corrects the central clock frequency to ensure minimum deviation.

Practical use

An essential difference between an E²PROM and other memory chips is

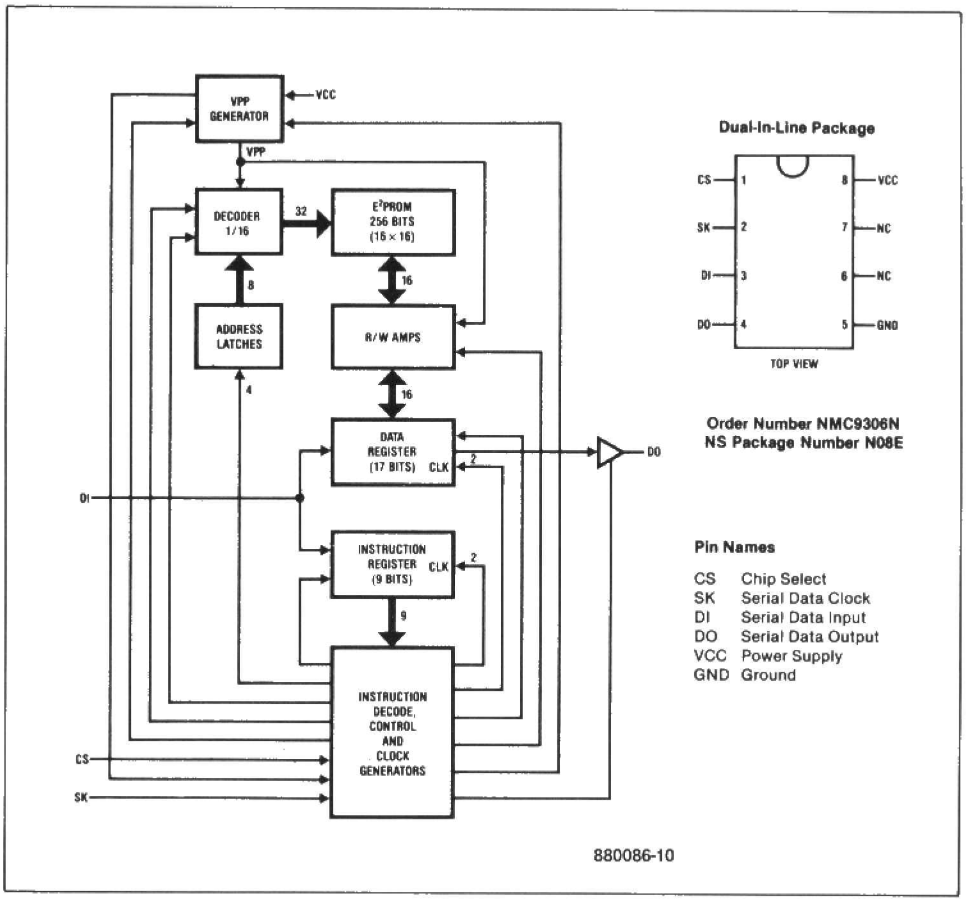


Fig. 1. Block and connection diagrams of E²PROM Type NMC9306.

apparent from the block diagram in Fig. 1. Data is sent to, and read from, the E²PROM via a serial interface, which not only makes it possible to house the chip in an 8-pin DIL package, but also makes its use independent of data- and address-bus structures — the E²PROM is simply a small peripheral device.

The serial input and output pins (DI and DO) may be controlled by separate serial formats. The serial interface is also used for reception, from the host microprocessor, of control commands for the E²PROM. These are 9-bit serial datawords, in which the start bit is always logic high. The next 4 bits form the opcode (see Fig. 2), followed by another 4 bits that form the register address.

The function of the E²PROM control commands can be summarized as follows:

- **Read:** data is first loaded into the data shift-register, and then shifted out via the serial output DO. The shift-out operation is clocked by the low-to-high transition of the signal applied to the SK input. A dummy bit (logic 0) precedes the 16-bit data output string. Only the read instruction causes serial data to be output via the DO line.
- **Erase/write enable (EWEN):** this command should always precede data erasure or loading operations.
- **Erase register:** unlike a RAM, an E²PROM register should be cleared (erased) before loading it with new data.
- **Erase all registers:** similar to the above command, but works on the whole chip rather than on an individual register.
- **Write:** load data in a previously cleared register.
- **Write all registers:** the same data is written to all registers.
- **Erase/write disable:** this command prevents accidental clearing or overwriting of registers.

Instruction	SB	Op Code	Address	Data	Comments
READ	1	10xx	A3A2A1A0		Read register A3A2A1A0
WRITE	1	01xx	A3A2A1A0	D15–D0	Write register A3A2A1A0
ERASE	1	11xx	A3A2A1A0		Erase register A3A2A1A0
EWEN	1	0011	xxxx		Erase/write enable
EWDS	1	0000	xxxx		Erase/write disable
ERAL	1	0010	xxxx		Erase all registers
WRAL	1	0001	xxxx	D15–D0	Write all registers

NMC9306/COP494 has 7 instructions as shown. Noje that MSB of any given instruction is a "1" and is viewed as a start bit in the interface sequence. The next 8 bits carry the op code and the 4-bit address for 1 of 16, 16-bit registers.

X is a don't care state.

880086-11

Fig. 2. Instruction set of the NMC9306 16×16-bit E²PROM.

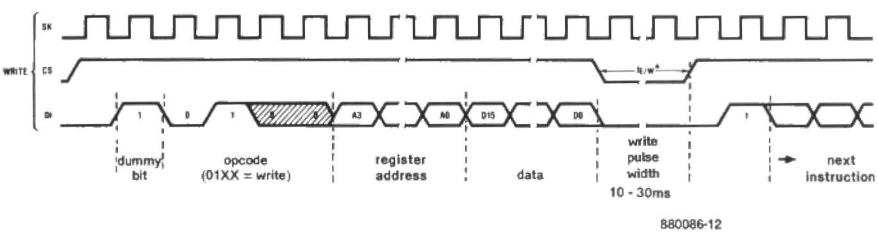


Fig. 3. Timing of the E²PROM write cycle.

Two control lines on the E²PROM arrange the timing. Low-to-high clock transitions on line SK (serial data clock) control the shifting in and out of data and commands. The maximum clock frequency is 250 kHz. Line CS (chip select) is active high, and enables or disables all data and command I/O operations. It also serves to time the erasure and programming pulses, which should have a duration of 10 to 30 ms. After the loading of a clear or write command, the relevant cycle starts when CS goes low. Programming lasts until CS reverts to logic 1. In the mean time, input SK is disabled. After programming has been completed, CS may remain logic high to enable loading a new command. When CS is made logic low, the E²PROM is switched to the low-power mode. In between commands, the minimum low-time of CS is 1 μs.

Reference:

1. Microcontroller-driven power supply. *Elektor Electronics* May 1988, June 1988, September 1988.

NEWS

MILLIMETRE WAVEBANDS SET FOR COMMUNICATIONS BOOM

Britain plans to take a lead in talks just starting on the European harmonization of frequency allocations that will be needed as a result of the opening of a section of the radio frequency spectrum above 30 GHz. Experts believe that the commercial use of this waveband will lead to a communications boom with such things as leadless office telephones and personal pen-sized telephones that may be carried in the pocket.

Radio frequencies above 30 GHz have until now been little used because of the high cost of equipment for operation in this band.

MORE TELECOMMUTERS?

A report from the Henley Centre for Forecasting, commissioned by British Telecom, predicts that the number of telecommuters—people who travel to work down the telephone line rather than by train or car—will soar from around two million today to some 14.5 million by 1995.

Furthermore, the high-tech home of the future will be controlled by a telephone call to operate a cooker, switch on the central heating, and even draw the curtains, according to the report.

NEW-TECH COMMUNICATIONS FOR ROUND-THE-WORLD RACE

The 1989 Whitbread round-the-world yacht race is to be provided with the most sophisticated global communications and information system yet devised for such an international event.

Using technology currently being developed at British Telecom's Martlesham research laboratories, British Telecom International (BTI) will provide computer graphics that will display the position of the yachts throughout the eight-month long race. The system will use regularly updated data transmitted from each yacht so that a range of information and graphic displays will be available to the race organization headquarters in Portsmouth.

COMPOSITE - TO - TTL ADAPTOR FOR MONOCHROME MONITORS

Among the welcome side-effects of the current invasion of IBM PCs and compatibles are the drastic price cuts for high-resolution, 12 and 14 inch, TTL-compatible monochrome monitors. The circuit described here makes it possible to use such a display in conjunction with a computer that has a composite video output only.

Many owners of popular home computers must at some time have been envious of IBM PC users, because these are in a position to look at text and graphics on a restive, high-resolution, non-glare monitor instead of on a (modified) TV set tuned to channel 36, and barely capable of displaying 80 characters per line. Until recently, however, the cost of a TTL monitor was such that manufacturers of home computers in the lower price ranges did not even consider equipping these with a digital output. The inexpensive adaptor circuit described here should allow many owners of the first generation of home computers to benefit from the advantages offered by the TTL-compatible monitor.

Circuit description

The circuit shown in Fig. 1 effectively splits the CVBS (composite video-blanking-synchronisation) signal applied to the input into three components: horizontal and vertical synchronization pulses, and video. These three signals are then converted to digital level to enable driving the corresponding inputs on the TTL monitor.

The low reference level of the CVBS signal is first set to 0 V by an active clamping circuit around IC_1. Figure 2 shows the voltage levels in a CVBS signal. Note that the amplitude of U_{sync} is usually about one third of that of U_{video}. The switching threshold of comparator IC_2 is set such that only the synchronization pulses can cause the opamp output to go low. The composite sync signal is then fed to XOR gate N_1 and to a two-section R-L-C low-pass filter. Switch S_1 connected to pin 2 of N_1 selects the signal polarity at the H-sync output. The presence there of V-sync pulses has no consequence for the TLL monitor. The V-sync pulses obtained after filtering in the low-pass can be inverted, if necessary, by closing S_2. Inversion is probably not necessary for most types of monitor, but users are well advised to consult the relevant manual in case of doubt.

A fast comparator, based around opamp Type 733 (IC_3) and FETs T_1-T_2, extracts the video component from the CVBS input signal. It should be noted that the attainable contrast ratio is mainly determined by the speed of the opamp, so that the circuit does not work correctly if IC_3 is replaced by a slower type. The toggle point of IC_3 is set to the average video level by P_2. Impedance conversion between the opamp and the digital video input of the monitor is achieved with T_4 and T_5, the latter functioning as an adjustable zener diode.

Construction, setting up and application

The adaptor is constructed on the printed circuit board shown in Fig. 3. The two inductors are preferably ferrite-encapsulated radial types from Toko. The completed unit can be installed in the monitor, which usually has room to spare inside. This has the advantage that the adaptor can be fed from the existing power supply, ensuring correct interface levels (check the specification of the monitor in this respect). As shown in the circuit diagram, the adaptor is uncritical of the supply voltage level, as long as this is between 5 and 12 V, and well regulated.

An oscilloscope enables the unit to be aligned quickly. With reference to Figs. 2 and 3, measure the levels $\frac{1}{2}U_{sync}$ (x), and $U_{sync} + \frac{1}{2}U_{video}$ (y), and set these voltages as the toggle levels for IC_2 (P_1) and IC_3 (P_2) respectively. Adjust P_3 for optimum picture resolution and stability. When an oscilloscope is not available, set P_2 and P_3 to the centre of

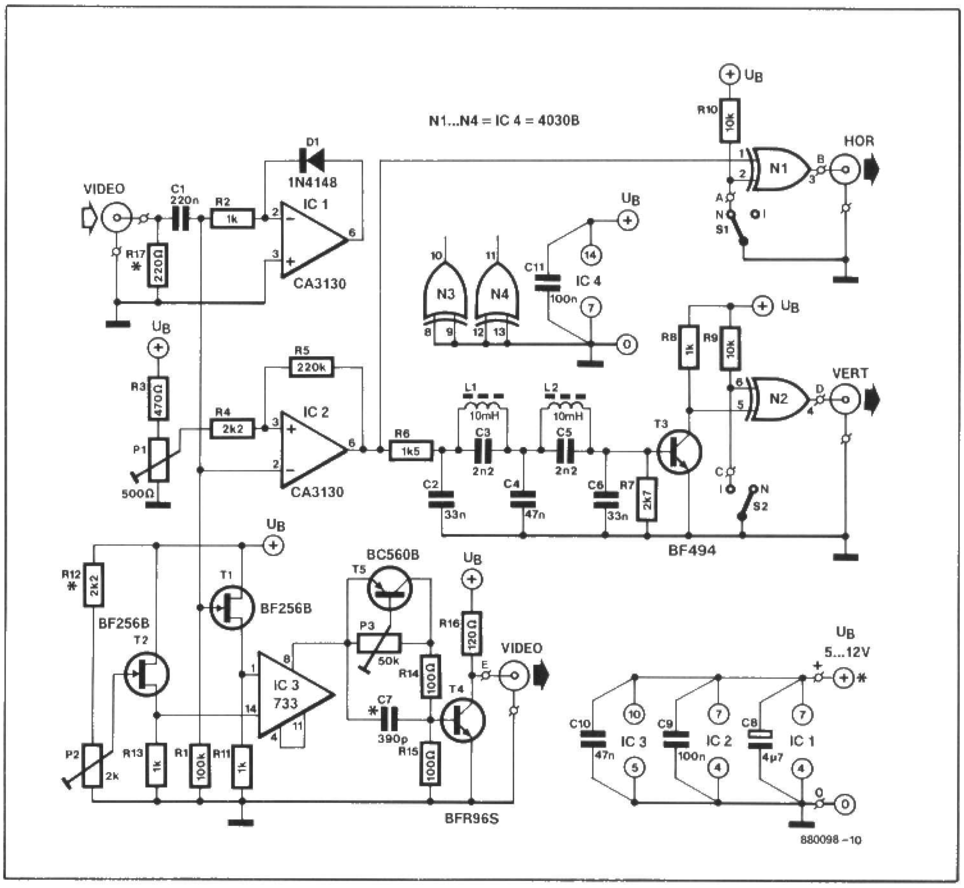


Fig. 1. Circuit diagram of the composite-to-TLL converter.

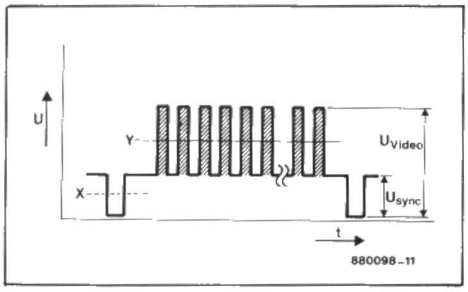


Fig. 2. Toggle level for the sync comparator (X) and for the video comparator (Y).

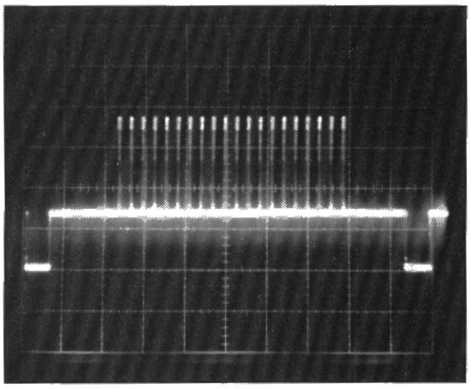
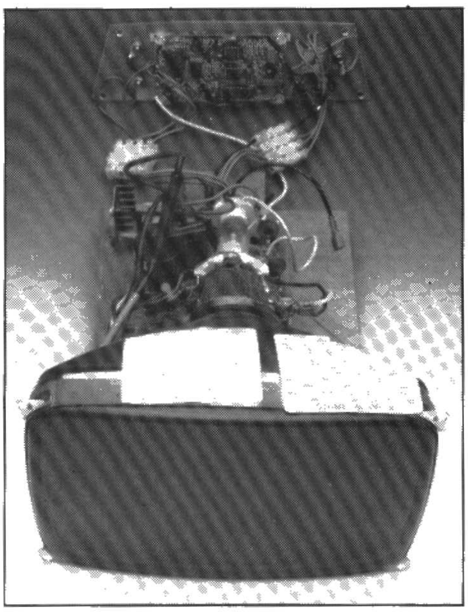
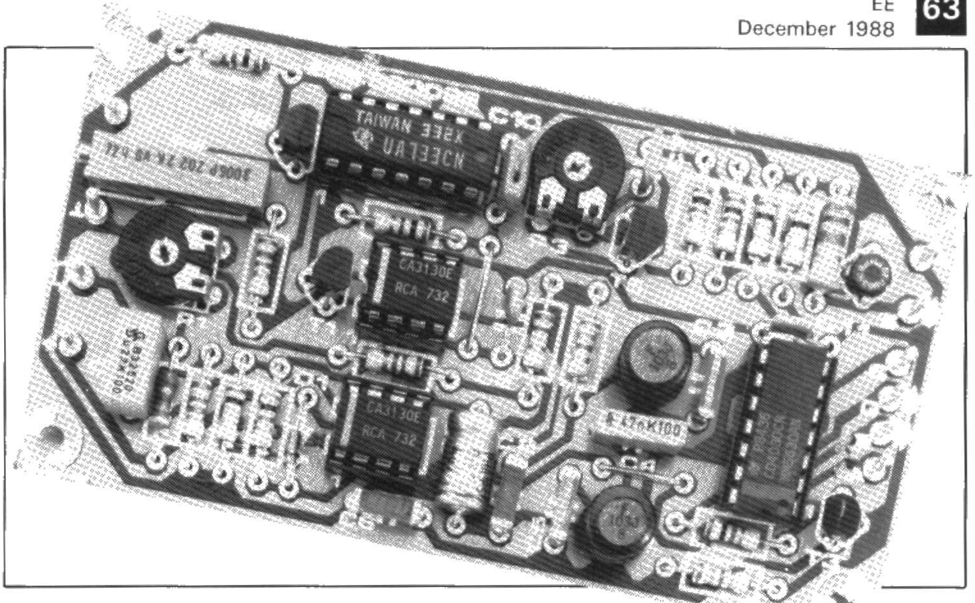


Fig. 3. Oscilloscope display of one line of text in a monochrome CVBS signal supplied by a BBC model B computer.

their travel, and turn the wiper of P_1 to ground. Apply the input signal, and carefully advance P_1 until the picture synchronizes. Then adjust the other two presets for optimum picture quality, first P_2 and then P_3.

The circuit is dimensioned to work with input video levels between 1 V_{pp} and 4 V_{pp}. The value of R_{17} may have to be increased, or the resistor may have to omitted, to ensure correct operation with home computers whose output level is lower than 1 V_{pp}. Signal levels exceeding 4 V_{pp} can be accomodated by lowering the value of R_{12}. Capacitor C_7, finally, also allows some experimenting because it may not be required unless a very high resolution monitor (>80 characters per line) is being used.





Populated printed circuit board.

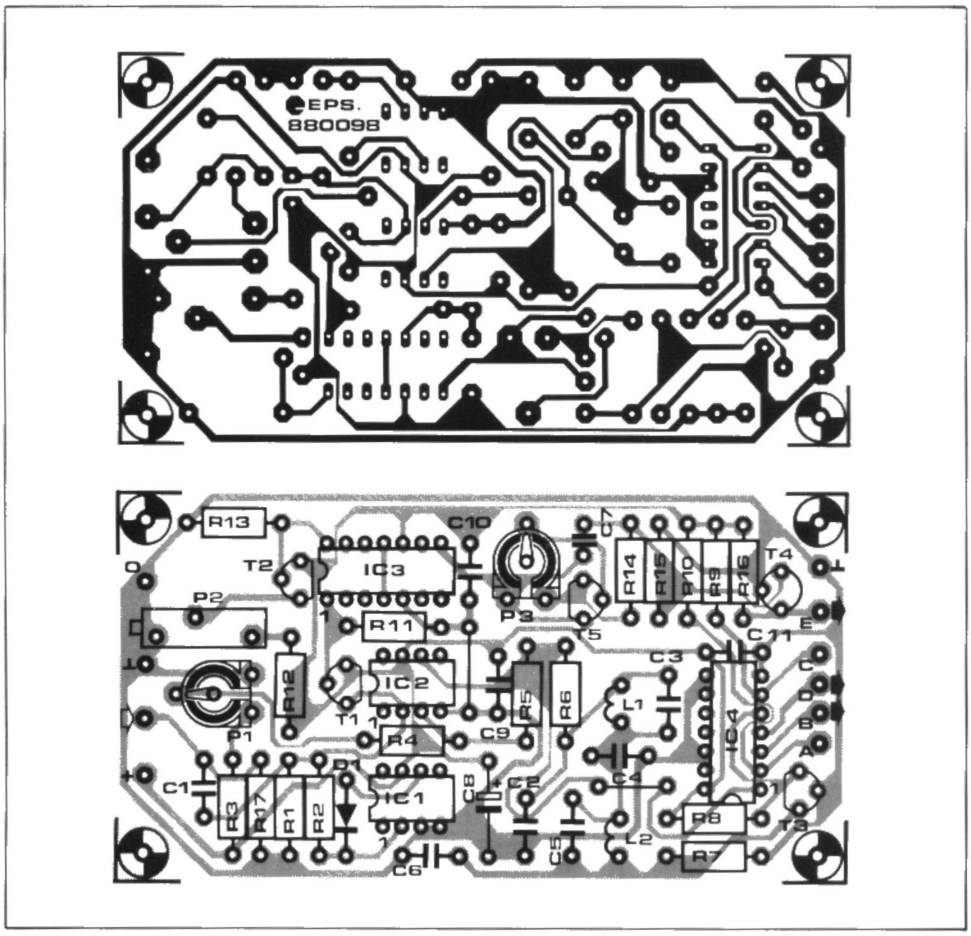


Fig. 4. Printed circuit board for the adaptor.

Parts list

Resistors (±5%):
R_1 = 100K
R_2;R_8;R_{11};R_{13} = 1K0
R_3 = 470R
R_4;R_{12} = 2K2
R_5 = 220K
R_6 = 1K5
R_7 = 2K7
R_9;R_{10} = 10K
R_{14};R_{15} = 100R
R_{16} = 120R
R_{17} = 220R
P_1 = 500R preset H
P_2 = 2K or 2K5 multiturn preset
P_3 = 50K preset H

Capacitors:
C_1 = 220n
C_2;C_6 = 33n
C_3;C_5 = 2n2
C_4;C_{10} = 47n
C_7 = 390p
C_8 = 4µ7; 16 V
C_9;C_{11} = 100n

Semiconductors:
D_1 = 1N4148
T_1;T_2 = BF256B
T_3 = BF494
T_4 = BFR96S (listed by Bonex Ltd.)
T_5 = BC560B
IC_1;IC_2 = CA3130
IC_3 = uA733 or LM733
IC_4 = CD4030B

Miscellaneous:
L_1;L_2 = 10mH radial inductor, e.g. Toko Type 181LY-103 (Cirkit stock no. 34-10302).
S_1;S_2 = miniature SPST switch.
PCB Type 880098 (see Readers Services page).

GUIDING THOSE WAVES

by W.D. Higgins

An increasing number of engineers have to consider processing signals in the gigahertz frequency range: satellite TV, information/data systems, point-to-point microwave links, and radar are but a few examples of fields where a basic understanding of the operation of waveguides is required, and where this brief 'guide to waveguides' may prove useful as an introduction.

A waveguide is essentially a precision-engineered length of hollow, usually rectangular, aluminium, invar, copper or brass (70/30 and 90/10) tubing that serves to carry microwave RF signals. Whereas professional-grade coaxial cable is used up to about 3 GHz with considerable attenuation, certain types of waveguide are suitable for carrying RF signals at frequencies of 50 GHz and higher, at an insertion loss that remains negligible even for relatively long runs. Waveguide technology can be treated as a very fine art, but is in principle very similar to conventional plumbing. Since waveguides and ancillaries such as coupling flanges, preformed twists, T-junctions and coaxial transitions are available ready-made in a variety of sizes, the engineer will have to decide on the most appropriate practical size of the waveguide, bearing in mind cost and machinability. To these factors must be added the technical consideration whether or not a particular waveguide size can be used at the frequency of interest. The physical size of a waveguide determines the *lowest* frequency at which it can be used, i.e., at which it is capable of propagating RF energy in a relatively loss-free manner. Any type of waveguide, therefore, has its specific cut-off frequency, below which attenuation rises rapidly.

The dominant propagation mode in a waveguide is referred to as TE_{10}. The distribution of the electric and magnetic field in TE_{10} mode is illustrated in Fig. 1. The electric field strength is maximum at the centre of long walls of the waveguide, and decreases sinusoidally to nought towards the short walls. The magnetic field has a loop-like configuration, and is distributed in parallel with the long wall of the waveguide.

To prevent excessive attenuation, the TE_{10} mode requires a minimum size of the internal waveguide width, w, of 0.5λ. The previously mentioned cut-off frequency therefore corresponds to a wavelength, λ_c, equal to $2w$. Width w should not exceed λ to prevent the dominant mode changing from TE_{10} to another electromagnetic pattern whose structure causes matching problems at the input and output of the waveguide. In practice, w is made slightly greater than 0.5λ because the wavelength of a signal in a waveguide, λ_g, is greater than the free-space wavelength, λ_0:

$$\lambda_g = \frac{\lambda_0}{\sqrt{1 - (\lambda_0/2w)}}$$

This equation applies to the TE_{10} mode, and shows that λ_g approaches infinity as w approaches 0.5λ. In practice, the minimum value of w is chosen between 0.6λ and 0.95λ to prevent components or joints in the waveguide causing propagation discontinuities or electrical losses. Similarly, to prevent polarization reversal between the input and output of the waveguide, the internal height, h, is chosen lower than 0.45λ. The maximum frequency of operation of a waveguide is usually $2f_c$.

Standard range

Most manufacturers of precision waveguides produce a standard range of sizes (and materials) that conforms to various European and US specifications. European specifications include IEC153 (1&2), DIN47302, BS9220, DEF5351 and CCTU10-20. US specifications include MIL-W-85C, EIA, RS261-A and JAN-MIL.

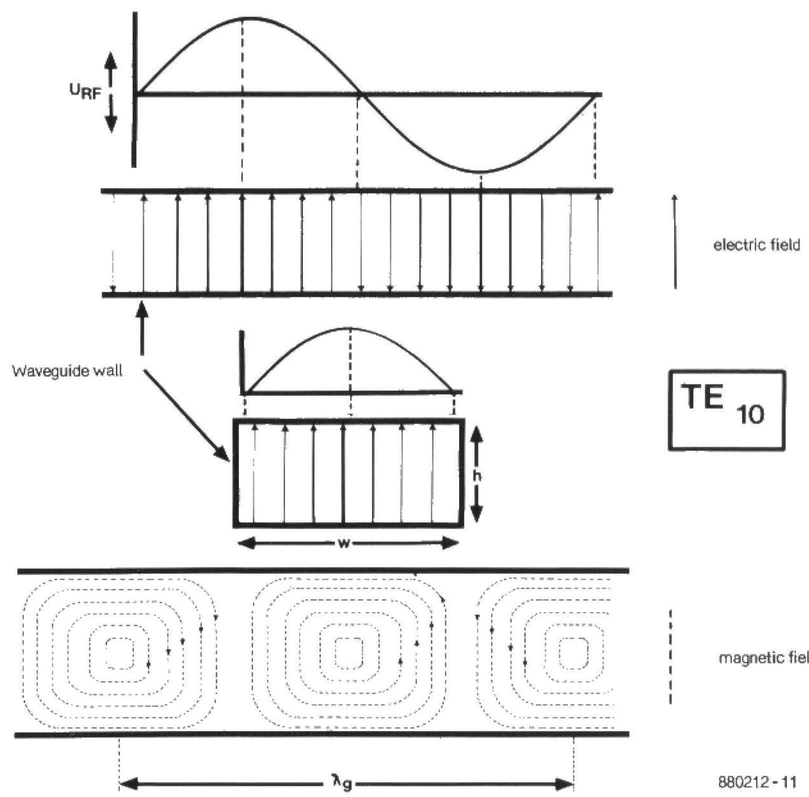


Fig. 1. Relative intensity of the electric and magnetic component in TE_{10} mode.

Waveguide size is denoted by a WG number. The most commonly used sizes are in the range WG5 to WG28 — the higher the WG number, the smaller the waveguide, and the higher the cut-off frequency (remember that this is the *lowest* frequency at which the waveguide can be used). Table 1 gives data of a number of waveguide sizes.

As a rule of thumb, the attenuation of a waveguide increases with length and the WG number. A few examples of typical attenuation figures are included in Table 1. WG16 is particularly popular among radio amateurs for use in 3-cm (X-band) and home-made Ku-band equipment (satellite TV reception). Ex-military waveguide systems are often offered in a variety of configurations at rallies, and by electronic surplus stores. Often, such units come complete with associated SHF electronic parts, such as Gunn-diodes, klystrons, adjustable attenuators, mixer diodes and even horn aerials. Waveguide circulators also exist, but are hard to get hold of.

The usual way of joining lengths of waveguide is by means of flanges. These are slipped over the waveguide and then brazed or soldered in place. Excess waveguide is usually milled or filed away. Great care should be taken to keep the inside of the waveguide free from residual solder, as this introduces high losses. In general, discontinuities smaller than 0.1λ are tolerable, so that it is perfectly possible to make one's own waveguide (and even flanges) from available brass or aluminium tubing. Waveguide tee-pieces, adjustable matching pieces, cross-couplers, dummy loads, tuneable filters, coax adaptors, twists and bends, flexible connecting pieces and directional couplers are available for most types of waveguide. Factors to consider when joining lengths of waveguide, or inserting connectors in a waveguide sys-

Table 1.

WG number	Inside dim. Outside dim. w × h (mm)	Attenuation (dB/m)	Frequency range (GHz)	Cut-off frequency (GHz)	Weight (kg/m)	Radio Band
5	195.6×97.8		0.96 to 1.46	0.77		
6	165.1×82.6 169.2×86.6	0.00522	1.14 to 1.73	0.91	9.72	L-band
7	129.5×64.8		1.45 to 2.2	1.16		
8	109.2×54.6 113.3×58.7		1.72 to 2.61	1.37		
9A	86.4×43.2 90.4×47.2		2.2 to 3.3	1.74		
10	72.2×34.0 76.2×38.1		2.6 to 3.95	2.08		S-band
11A	58.2×29.1		3.3 to 4.9	2.6		
12	47.5×22.1 50.8×25.4	0.0355	3.95 to 5.85	3.15	2.18	
13	40.5×20.2		4.9 to 7.05	3.71		C-band
14	34.8×15.8 38.1×19.1		5.85 to 8.18	4.3		
15	28.8×12.6 31.8×15.9		7.05 to 10.0	5.3		
16	22.9×10.2 25.4×12.7		8.2 to 12.4	6.6		X-band
17	19.1×9.5		10 to 15	2.9		
18	15.8×7.9	0.176	12.4 to 18	9.4	0.48	
19	12.9×6.5		15 to 22	11.6		Ku-band
20	10.7×4.3 12.7×6.4		18 to 26.5	14		
21	8.6×4.3		22 to 33	17.3		Ka-band
22	7.1×3.6 9.1×5.6		26.5 to 40	21.1		
23	5.7×2.8		33 to 50	26.3		
24	4.8×2.4	1.06	40 to 60	31.4	0.168	
25	3.8×1.9		50 to 75	39.9		mm-band
26	3.1×1.6		60 to 90	48.4		
27	2.5×1.3		75 to 100	59		
28	2.0×1.0		90 to 140	73.8		

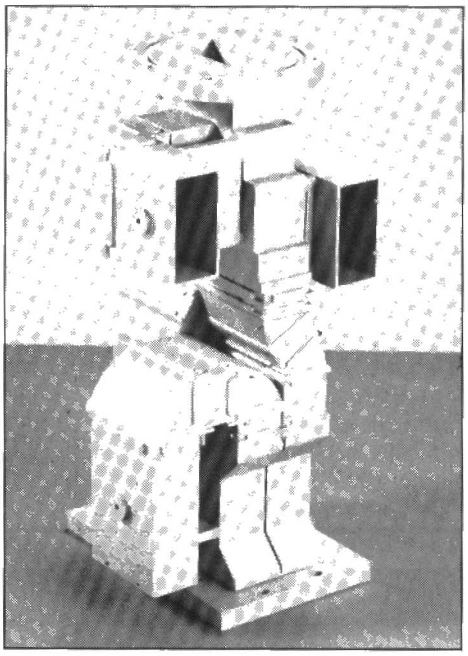


Fig. 2. Not a decapitated robot, this, but a 4-port phase shifter for new high-power C-band radars currently under development in the USA and Sweden. *Photograph courtesy of MM Microwave.*

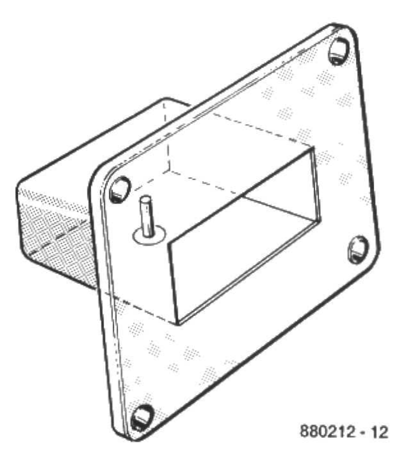


Fig. 3. WG-16 waveguide input of a low-noise block down converter (LNC) for Ku-band satellite TV reception.

tem, include the frequency range, VSWR of all ports, power division, port-to-port RF isolation, phase balance, power handling, polarization and, of course, physical parameters.

Future trends

As greater use is made of the microwave bands, the demand for waveguides, and with it SHF research and development, is found to increase. In the field of metallurgy, new alloys may be invented with better physical characteristics, to reduce attenuation, improve machinability, and allow greater power handling.

Addresses of companies handling waveguides:

Du-Keren c/o Frequency Techniques • Cornwallis House • Howard Chase • Basildon • Essex SS14 3BB. Telephone: (0268) 293401.
Evered • P.O. Box 21 • Lewisham Road • Smethwick • Warley • West Midlands B66 2BW. Telephone: (021 555) 5885.
Flann M.I. • Dunmere Road • Bodmin • Cornwall PL31 2QL. Telephone: (0208) 3161.

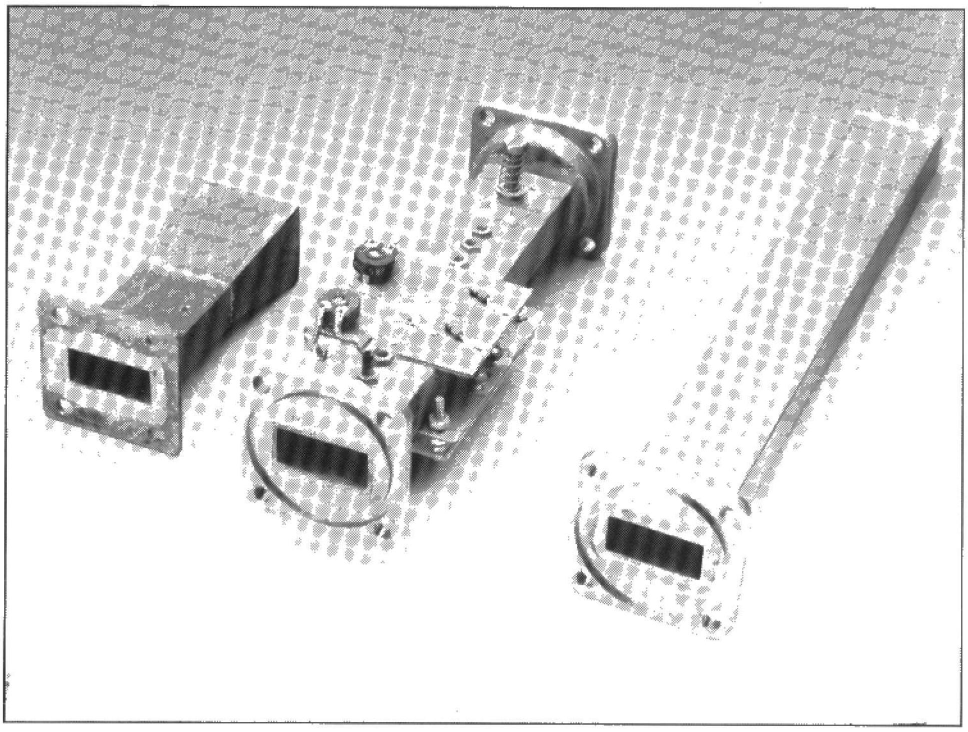


Fig. 4. A piece of WG16 waveguide fitted with one flange, a small horn aerial, and a home-made two-stage Ga-As FET preamplifier for Ku-band satellite TV reception, fitted on to a length of brass waveguide. Input and output coupling to the waveguide is effected with internal ¼λ probes.

MM Microwave Ltd. • Thornton Road • Pickering • North Yorkshire YO18 7JB. Telephone: (0751) 76363.

H. Rolett &Co. Ltd. • Howie Street • London SW11 4AR. Telephone: (01 228) 7872.

EVENTS

IEE Meetings

2 Dec. The RDS system—its implementation and use.
5 Dec. Frequency spectrum management.
7 Dec. Sea traffic control—the impact of electronic technology.
8 Dec. Cassini—the mission to survey Saturn and land on Titan.
12 Dec. CD ROM.
12 Dec. The future of telecommunications in the leisure industry.
13 Dec. Recent developments in engineering design concepts.
13—14 Dec. Satellites and broadcasting.
15 Dec. Digital signal processing for VLSI.
19 Dec. Digitized speech communication via mobile radio.

Details on these events may be obtained from The Secretary • IEE • Savoy Place • LONDON WC2R 0BL • telephone 01-240 1871.

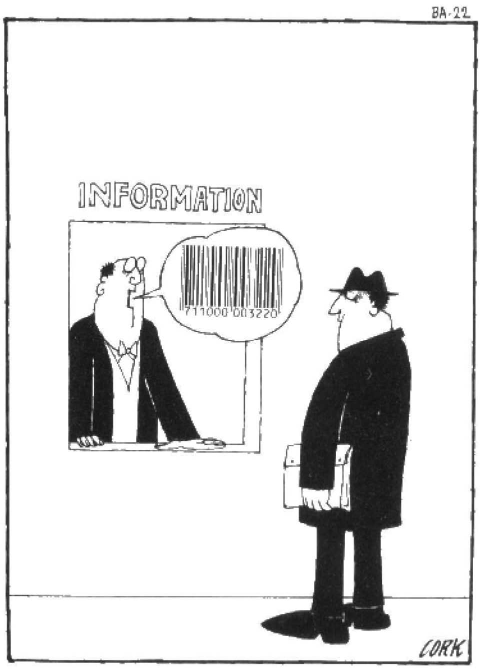
The **Third Annual Computer and Technology Show** organized by SATRO (Science and Technology Regional Organization) will be held at the Music Hall, Aberdeen, on Sunday 11 December. Details from SATRO (Dr Lesley Glasser) • Marischal College • University of Aberdeen • Broad Street • ABERDEEN AB9 1AS • Telephone (0224) 273161.

The 1988 **Data Acquisition Show** will be held at the National Exhibition Centre, Birmingham, from 29 November to 1 December.
Details may be obtained from Bush Steadman & Partners Ltd • The Hub • 9 Emson Close • SAFFRON WALDEN CB10 1HL • Telephone (0799) 26699.

The **European Satellite Communications Conference** will be held at BAFTA, London, on 1—2 December.
The **Electronic Messaging Systems Conference** will be held at the Tara Hotel, London, on 6—8 December.
Details of these two events may be obtained from Blemheim Online • Blenheim House • Ash Hill Drive • PINNER HA5 2AE • Telephone 01-868 4466.

The **European Communications Week** will be held in Amsterdam from 6 to 9 December.
Details from RAI Exhibitions, telephone 01-741 4437.

An **International Telecommunications Equipment Exhibition** will be held in Hong Kong from 10 to 13 December.
Details from ADG Exhibitions, telephone (02403) 29406.



LOOKING BACK

Updates, applications and improvements for recently published projects

Stereo limiter

(*Elektor Electronics* January 1988, p. 57-59).

The operation of this design can be improved with a few minor alterations, which have to do mainly with the DC bias of the gain cells in IC_3. To begin with, C_3 and C_{10} are replaced by wire links. This upsets the DC bias of A_5 and A_6, however, so that further modifications are required. The positive (non-inverting) inputs are taken to pin 6 and pin 10 of IC_3 instead of to ground. Further, R-C networks are fitted across R_5 and R_{12} to reduce the direct voltage gain to about unity. The R-C networks only provide negative feedback for direct voltage, and do not, therefore, affect the AC gain. The last modification entails connecting an electrolytic capacitor in series with R_6 (R_{13}). The modified circuit diagram of the stereo limiter is given in Fig. 1.

On the printed circuit board, replace C_3 and C_{10} by wire links. The R-C networks are soldered direct across R_5 and R_{13}. Remove IC_2 from its socket and bend up pins 3 and 5 before re-inserting the chip. Use short lengths of insulated wire to connect pins 3 and 5 with the indicated pins of IC_3.

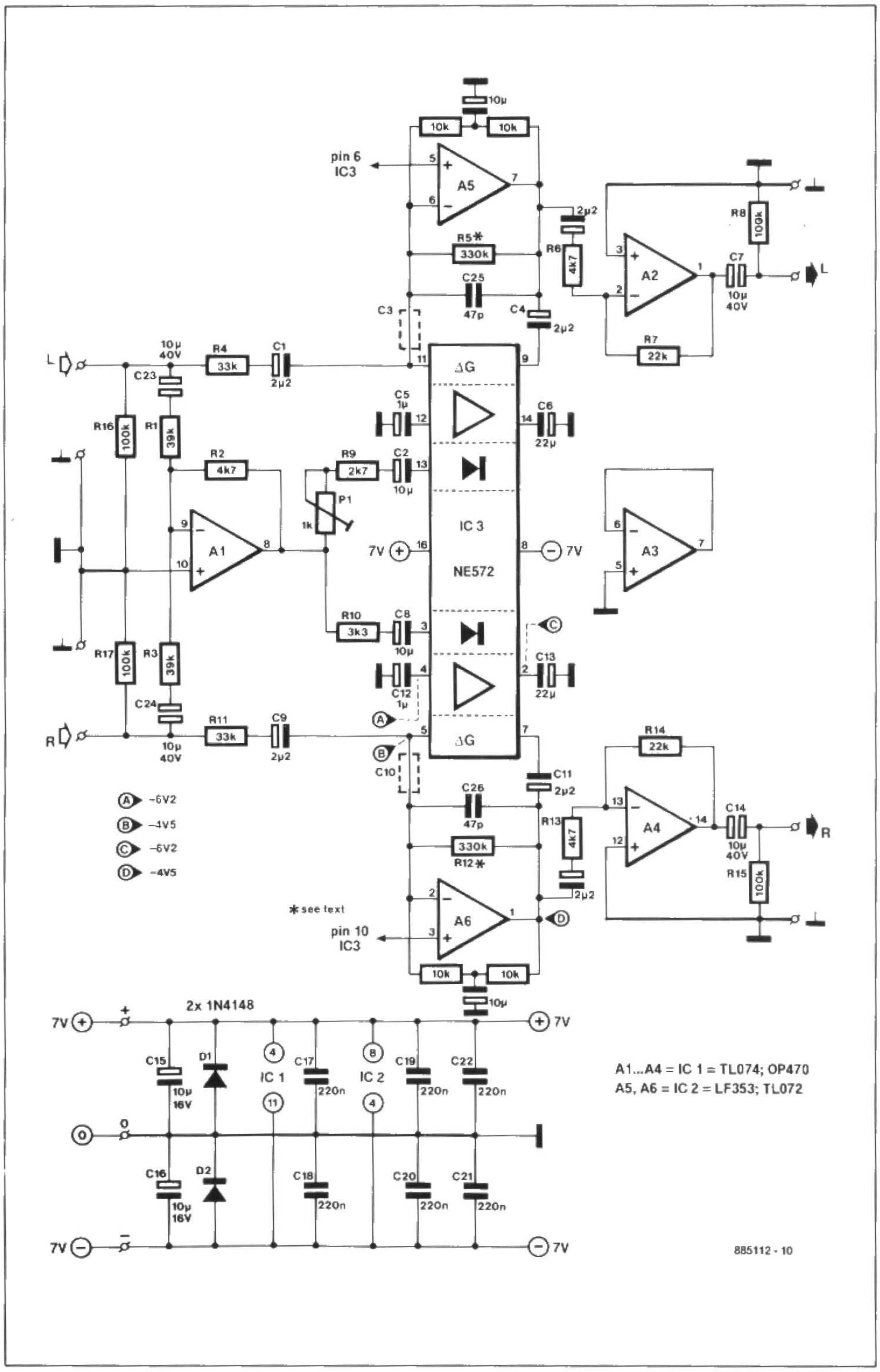


Fig. 1. Modified circuit diagram of the stereo limiter.

HF operation of fluorescent tubes

(*Elektor Electronics* June 1988, p. 36-43).

Control of more than one tube.

As stated in the article, the controller is, in principle, suitable for powering one tube only. When two tubes ar connected in parallel, a problem arises during starting. Normally, when one tube is connected, resonance will occur at some point when the VCO frequency swings from 80 kHz to 30 kHz, and it is at this point that the tube is started. With two tubes in parallel, one will always start first, causing damping of the resonance circuit and making it impossible for the other to start. Simultaneous starting of the tubes is possible, but a matter of pure chance. Moreover, the current control

circuit and power output stage of the tube controller are not capable of handling double the current.

Series connection of fluorescent tubes offers better prospectives, but works only with relatively low-power tubes of up to 2×20 W. The connection diagram is shown in Fig. 2. Capacitor C_1 is omitted from the board, and 'split up' in C_{1a} and C_{1b}. During starting, C_{1a} and C_{1b} ensure a current flow through all tube filaments, and at the same time provide equal distribution of the start voltage. Since C_{1a} and C_{1b} are connected in series, their value should be double that of C_1 (see Table 1 in the article) to give the correct equivalent capacitance. Two series-connected fluorescent tubes of 20 W each are now equivalent to a single 40 W tube.

Following the simultaneous ignition of the tubes, these can be dimmed as if they were one tube. It will be noted, however, that the point of minimum brightness (set with P_2) is slightly less favourable than with one tube. This is so because at a certain point one tube will go out, but its parallel capacitor will tend to keep the other on. This effect can be explained by the highly irregular impedance characteristic of the fluorescent tube, which behaves like a current-dependent resistance. Series connection of fluorescent tubes is best done with types of the same manufacturer, wattage and age.

There is no way to go round building the required number of HF controller boards when connecting, for instance, two tubes of more than 30 W, or 4 tubes of 20 W. Fortunately, these can still be dimmed simultaneously with a central control as shown in Fig. 3. In this set-up, it is important that the mains connections to the controller boards are in phase.

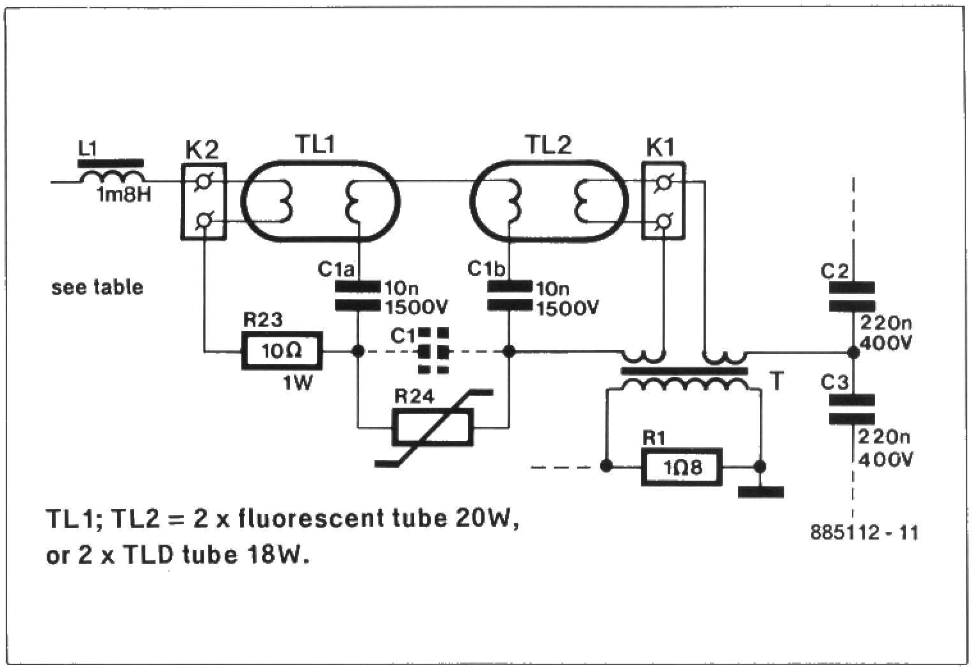


Fig. 2. One controller board connected to two fluorescent tubes.

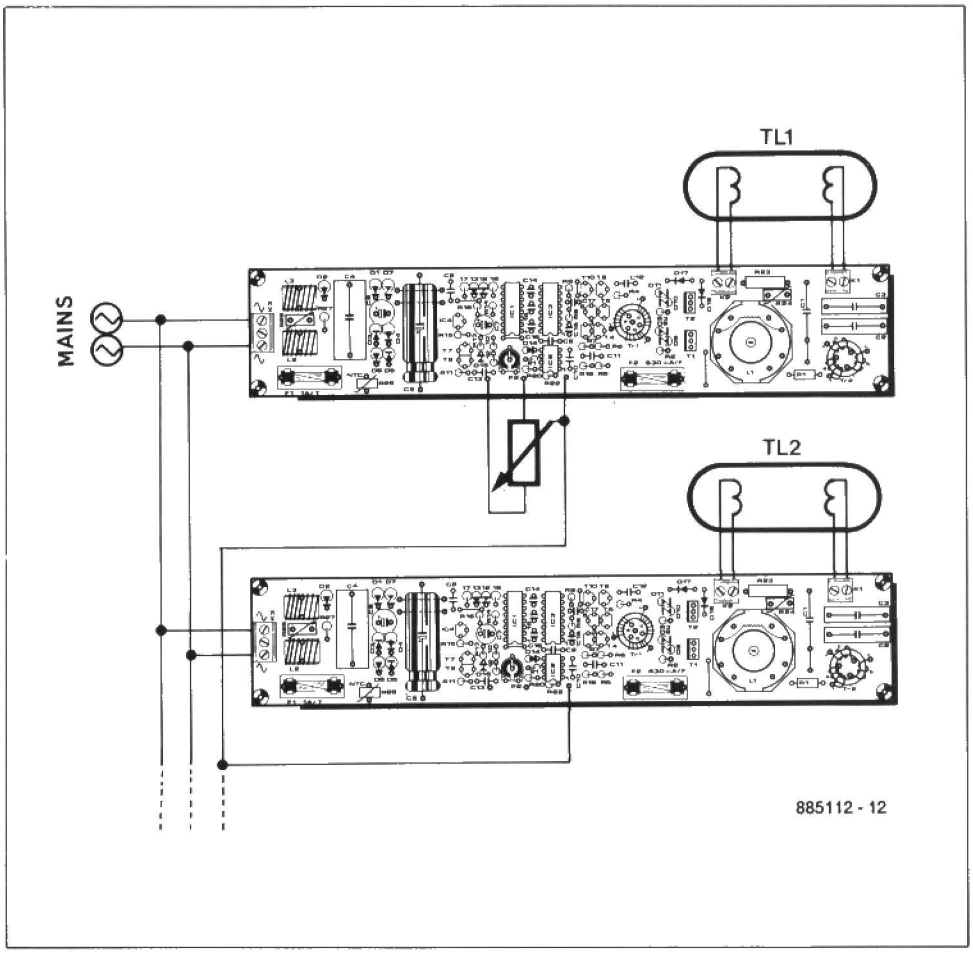


Fig. 3. Showing how controller boards can share the intensity control potentiometer.

Cable length between controller and tube.

A cable of several metres length is, in principle, no problem as long as its capacitance is low relative to that of C_1. In practice, this means that cables from K_1 should not be allowed to run too close to those from K_2. It is still strongly recommended to fit the controller board as close as possible to the tube, with adequate ventilation, because the use of a relatively high switching frequency on a long cable is bound to introduce a strong electromagnetic field which causes radio and TV interference. The use of shielded wire, however, is not recommended because it increases the capacitance to ground.

Oscillator stability.

The bias current of zener diode D_{12} in the control circuit is relatively low to reduce the current consumption of the control circuit. In some cases, the bias current is too low, however, and gives rise to instability of the zener voltage. This results in temperature dependence of the oscillator start frequency. To ensure reliable start behaviour of the circuit, it is recommended to redimension a number of components:

R_{16} is changed from 6K8 to 2K7;
R_{17} is changed from 39K to 15K;
C_7 is changed from 100 μF to 220 μF.

A timer/controller for aquarium lighting is currently under development.

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Letters of a general nature, or expressing an opinion, or concerning a matter of common interest in the field of electronics, should be addressed to The Editor. Their publication in *Elektor Electronics* is at the discretion of the Editor.

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